Neuroimaging and mediumship: a promising research line

Neuroimagem e mediunidade: uma promissora linha de pesquisa

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Received: 10/30/2013 – **Accepted:** 10/30/2013

Abstract

The mind-body relationship has prompted debate from the times of millennial religious traditions and the ancient Greeks through to contemporary neuroscience, and although these questions have yet to be decisively answered, therapeutic interventions today are guided by assumptions made in this respect. Research on the neural correlates of consciousness and mental expressions has made progress over the last 15 years by developing functional brain imaging methods. This approach may open up new perspectives for studies of the expression of presumed instances of spiritual consciousness, which would have major ethical, social and philosophical implications. We pose a promising new line of research in the neurosciences and discuss certain issues pertaining to the effective use of neuroimaging to investigate mediumship and advance the consensus comprehension of consciousness, alleged spiritual communication and its relations with the brain. We highlight methodological challenges and lessons gleaned from our neurofunctional study of mediumship to be considered for further research in this field when formulating hypotheses to address these phenomena, and discuss useful guidelines for neuroimaging studies of spiritual experiences in general.

Peres JFP, Newberg A / Rev Psiq Clín. 2013;40(6):225-32

Keywords: Mediumship, consciousness, dissociation, neuroimaging, SPECT.

Resumo

A relação mente-corpo tem despertado perguntas e debates desde os tempos das milenares tradições religiosas e dos antigos gregos até a neurociência contemporânea e, apesar de essas questões ainda não terem sido decisivamente respondidas, atualmente intervenções terapêuticas são orientadas por suposições a esse respeito. As investigações sobre os correlatos neurais da consciência e expressões mentais progrediram ao longo dos últimos 15 anos por meio do desenvolvimento de métodos de imagiologia funcional do cérebro. Essa abordagem pode abrir novas perspectivas para investigação da expressão de consciências supostamente espirituais com importantes implicações éticas, sociais e filosóficas. Propomos uma promissora nova linha de pesquisa em neurociências e discussão de algumas questões pertinentes à efetiva utilização da neuroimagem como potencial método de investigação da mediunidade para avançar a compreensão consensual a respeito da consciência, da suposta comunicação espiritual e suas relações com o cérebro. Destacamos certos aprendizados e desafios metodológicos adquiridos em nossa pesquisa neurofuncional sobre mediunidade a serem considerados em novos estudos nesse campo para formulação de hipóteses a respeito de tais fenômenos e discutimos orientações úteis para estudos de neuroimagem envolvendo experiências espirituais em geral.

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Palavras-chave: Mediunidade, consciência, dissociação, neuroimagem, SPECT.

Introduction

There are currently several theories attempting to explain consciousness and personality through an extensive range of hypotheses such as interactions of environmental, psychosocial, neural, genetic and spiritual factors[1-3]. The origin and supposed ending of "psychic life" have been debated from millennial religious traditions and the ancient Greeks to contemporary neuroscience, but no consensus has been reached[4-6]. Nevertheless, healthcare professionals do base their therapeutic interventions on a vision of man and his underlying nature[7-11]. Around 40% of American scientists believe in a personal God, and hold dualistic views of the mind-brain relationship[8] and 7.9% of scientists (members of the National Academy of Sciences) believe in life after death[12]. Assumptions concerning the mind-brain relationship have philosophical, scientific, and practical implications[3,13]. The etiology of human suffering, consciousness and the factors that constitute personality are essential concerns for professionals treating the numerous forms of psychic pain[10]. No theory of psychology may be seen as complete if it does not account for experiences considered paranormal/anomalous[14]. These experiences were found to be relatively common in the general population (48%) and those who reported them sometimes/often described them as highly significant[15]. Studies of mediumship – in which an individual (the medium) claims to communicate with (or be controlled by) the mind of a deceased person – are posed for this agenda of anomalous experiences. Pierre Janet's[16] classic study of dissociation, for example, examined several mediums; Carl Jung's[17] doctoral thesis involved a case study of mediumship; and William James[14] studied the medium Leonora Piper. More recently, some have found highly significant levels of correct responses from mediums[18,19] while other studies have reported below-significance results[20,21] prompting extensive methodological debate[19,20]. Hence the ongoing need for controlled studies of mediumship with appropriate criteria for researchers investigating whether mediums are capable of manifesting specific and precise information that has not been obtained through known sources, and if so, under what conditions[19]. Other lines of research are likely to be associated with investigation of mediumship, and we believe that neuroscience may contribute significantly by generating neurofunctional data to broaden knowledge of spiritual and mediumnistic phenomena in which the medium's consciousness and volition are supposedly attenuated, or even dissociated[22].

Investigations of the neural correlates of consciousness and mental expressions have made progress over the last 15 years by developing functional imaging methods[23,24], which have enabled

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researchers to observe the cerebral dynamics involved in supposedly unconscious coma/vegetative states, or minimally conscious states with paralyzed/locked-in syndrome[23]. The findings on activities of neural circuits related to cognitive understanding of apparently unconscious individuals helped improve psychological and medical therapies[25,26]. On the other hand, in light of the various hypotheses concerning the mind-brain problem, to be discussed below, we may also be able to observe attenuated brain activity during mediumistic activities, when a spirit is supposedly the author of contents that a medium is expressing in words, writing, painting etc. The neuroscientific approach may open up new perspectives for the investigation of the expression of supposedly spiritual consciousness with major ethical, social, philosophical implications, as well as in the health scope.

The theme proposed here involves a boundary area that has paradoxically been exhaustively covered by historical polemics that we shall briefly recap. Our aim is to pose a promising new line of research in the neurosciences and discuss certain issues pertaining to the effective use of neuroimaging as a potential method for investigating consciousness, supposed spiritual communicability, and its relationship with the brain.

The mind-brain debate in historical perspective

At the end of the 6th century BC, Croton in Magna Grecia had the most outstanding medical schools where diseases of the human body were examined experimentally rather than being ascribed to supernatural beings. Alcmaeon, one of the most active physician-philosophers interested in human physiology in the Croton medical tradition, declared that the soul was immortal and may well have been the first to pose the concept of the brain-mind relationship, identifying the brain as the center of understanding, perceptions, sensations and thoughts[27]. Further along this timeline, 18th-century neuro-philosophical arguments find an echo in mind-brain problem controversies today. The key neurophysiological concept at that time was Haller's doctrine of equipotentiality of brain structures, including the cortex. Shortly before 1800, in an attempt to reconcile philosophy and science, the anatomist Samuel Thomas Soemmerring suggested that ventricular fluids were the immediate organ of the soul. This hypothesis was then refuted with the ascent of phrenology – led by Franz Joseph Gall (1758-1820), postulating that personality and complex traits (combativeness, hope etc.) were controlled by brain regions that expanded as these traits developed – marking the cerebral localization debate at the end of the pre-modern era[28]. Today's philosophers and neuroscientists in the field of neuroethics cautiously discuss whether neuroimaging is really a revolutionary research tool or merely a more "sophisticated" reiteration of phrenology updated for the present period[29,30]. Also discussed are the ethical implications of the brain's purportedly autonomous production of mind, or the possible undermining of our individual responsibility due to the "biologization" of human experience[31]. After 2,500 years, contributions such as Alcmaeon's continue to influence debate between philosophers, naturalists and neuroscientists[32].

Some scholars have argued that belief in the soul is culturally universal[33,34], probably because it helps people explain the subjective experience of the mind itself, which seems to occur in a manner disconneted to any physical event[35]. In this respect, Dennett[36] argues that theological belief has evolutionary significance and may be advantageous for our inter-relations in light of "intentional stance" theory, when we explain behavioral or mental events of volition (or having "a will of their own"). Moreover, functional neuroimaging studies have shown neural correlates for many mental/psychological phenomena including moral judgments[37,38], emotional expressions[39] and neurobiological effects of psychotherapy[40,41]. This research has also caught the eye of the media and the general public. Vivid images of the brain "lit up" during mental activity seem to favor the layman's "concrete proof" that the mind is an expression derived from the brain. Despite the many advances in functional neuroimaging, there is still an epistemological question of the mind that neuroscience may not be capable of solving, which is termed the "hard problem of consciousness"[1] or the "explanatory gap"[42]. On the other hand, some reductionist materialists deny that there are "hard questions" to be answered or that there is any "explanatory gap", because the mind cannot exist separately from the brain: the mind is the brain. In this respect, mental experiences would be explained by brain activity alone[2].

Not a few Artificial Intelligence researchers believe that the human soul may be algorithmically compiled[43,44]. On this view, there is no "separation" between mental and physical phenomena and the mind is analogous to sophisticated cerebral software[45]. There is as yet no consensus account of the origin of the mind or how neurophysiological processes produce conscious experiences, feelings, and intentions. Despite recurring discussions, promissory materialism has not delivered[46,47]. Although neuroscience can clearly identify neural correlates associated with mental processes, it cannot explain precisely how cerebral activity creates mental-experience phenomena, and this gap leaves certain aspects of mind inexplicable, thus favoring implications for belief in the soul[5,48,49].

Biases to be deconstructed

Demertzi *et al.*[13] conducted two studies at Edinburgh University (students, n = 250) and Liège University (medical professionals and laymen, n = 1,858) to investigate opinions/attitudes about the mind-brain problem and variables that affect differences between points of view. Respondents were shown the following statements: (1) mind and brain are two distinct things, (2) the mind is fundamentally physical, (3) a spiritual part of us survives after death, and (4) each of us has a soul that is separate from the body. The first study found predominantly dualistic attitudes emphasizing separation between mind and brain. The second study found that younger participants, women, and people with religious beliefs were more likely to see mind and brain as separate, with some spiritual part of us surviving death, and each of us having a soul. Religious belief was seen as the strongest predictor of dualistic views. Although most health professionals rejected the distinction between consciousness and brain, more than a third of medical and paramedical professionals saw mind and brain as separate entities[13]. More recently, Preston *et al.*[48] studied a group of American psychology undergraduates and found that showing them texts posing strongly mechanistic explanations was associated with students' lower scores for belief in the soul, while pointing to the current limitations of neuroscience in explaining mind and consciousness was associated with higher scores for belief in the soul. In other words, neuroscientific explanations about neural correlates and cognitive faculties prompted less belief in the soul, whereas mention of the weaknesses of neuroscience in terms of explaining consciousness prompted more belief in the soul. 'Promissory materialism'[50] involves an expectation that science will be able to show how brain produces mind in the future. Although this expectation promised three hundred years ago[46] might materialize sometime, we cannot go on ignoring alternative explanations such as those proposed by Henri Bergson, William James, and Frederic Myers, namely that the brain acts as a filter rather than a cause of mental manifestations[3,51,52]. Therefore caution is required in relation to exaggerated interpretations of results. What some neuroscientists currently call 'neural bases' should be corrected to 'neural correlates' in light of current different hypotheses posed for the mind-brain relationship[3,22].

In short, theories concerning the genesis of consciousness may be divided into two categories: (1) those in which consciousness is a product of brain activity, and (2) those in which consciousness is an entity with its own life and functioning that is not necessarily restricted to the brain's. Neurofunctional research in this field should respect data without trying to make them fit one theory or another. On the other hand, until now, we have had few opportunities to test these theories experimentally. Thus, among other lines of research, neurofunctional studies of mediumship in particular may advance the

consensus comprehension of consciousness, spiritual communication, and their relations with the brain. In addition to studies of religious experiences, studies focused on purported spiritual communication may allow us to observe neural correlates in situations in which an individual and his/her brain are allegedly manifesting contents of another consciousness (the spirit) during a mediumistic trance, thus adding to our knowledge of the mind-brain complex.

Neurofunctional imaging and religious experiences

New technologies favor research on the neural correlates of complex experiences, since brain dynamics may be observed *in vivo* in controlled situations. The main methods used for the past 15 years are single photon emission tomography (SPECT), positron emission tomography (PET) and functional magnetic resonance imaging (fMRI)[53].

Deciding which method to use requires careful assessment of advantages and limitations[53,54]. Factors such as sensitivity to functional and anatomical detection (spatial and temporal resolution), ability to control and reproduce trials, as well as cost and the method's availability for use should ideally be weighed in relation to the proposed objective of investigation (Table 1). We used SPECT because it allows subjects to perform their complex tasks that require quiet and concentration, in a suitable setting free of many distractions or anxiety triggers. On the other hand, fMRI is a non-invasive method with higher spatial and temporal resolution (Table 1). However, noise should be controlled when rehearsing tasks prior to the study so that the mediumistic expression is not impaired.

Some current studies have shown that a range of brain regions and systems mediate different aspects of religious experience[55,57], thus discarding the "God spot" proposal[58]. Religious experiences are complex and multi-dimensional in as far as they involve altered perception (mental-visual imagery for example), cognition (such as self-representations), and emotion (being at peace, joy, and unconditional love)[57]. Functional studies tend to suggest greater activity in the frontal and prefrontal cortex during religious experiences[55-57,59,60]. The similarities between findings include increased activity in the attentional networks related to reflective assessment of thought during religious experience[55-57,59,60]. Others have contributed to our understanding of religious experiences by investigating drug-induced experiences[61] and the nature of religious belief[62,63]. They have also pointed to the activity of areas such as the frontal and parietal lobes that are correlated with specific psychological and cognitive elements of religious experiences. These structures appear to be part of a network involved in elaborating religious phenomena. Table 2 lists neuroimaging research on religious practices. Note that our own study of mediumship[22], unlike those of other religious practices such as meditation or prayer, found diminished activity in attentional networks during alleged spiritual communication. Similar findings occurred during the experience of glossolalia – "speaking in tongues" – in which individuals claim access a spiritual realm. Further studies are required to fill out details of the nature as well as differentiation of religious and spiritual practices, and their neural correlates.

A nascent line of research and methodological challenges

We used neuroimaging to investigate the practice of psychography, in which supposedly "a discarnate spirit writes through the medium's hand"[22]. Based on the experience gained in our study we shall proceed to discuss guidelines for further neuroimaging studies on the subject as well as those related to spiritual experiences in general.

Psychography is one of the many dissociative forms of expression in mediumship. While psychographing, mediums write structured and readable narratives but often claim to be unaware of content or grammatical structure. The aim was to investigate whether this type of dissociative trance state is related to specific cerebral activity alterations that are distinct from those observed when they are writing normally or in a non-trance state. Thus, we measured regional cerebral blood flow (rCBF) using SPECT during psychography (writing in dissociative trance state) and compared the data with those collected during writing in the habitual non-trance state of consciousness (control task). Our a priori hypothesis was that the areas involved in cognitive processes when writing consciously, such as reasoning and planning content, should show similar activation when subjects are writing in a mediumistic trance state.

We examined ten Brazilian mediums, whom we divided them into two groups – five "less experienced" mediums and five with "substantial experience". The comparison between experienced and and less experienced mediums may help to obtain more realistic neurofunctional data concerning this practice. William James[14] wrote that it was crucial to focus investigations on the most extreme manifestations of a phenomenon. Thus, there is a rationale for neurofunctional reports of isolated cases of mediums showing robust expression or decades of experience, which may favor more consistent findings. Meticulously screening samples is a particular challenge in this area of research. Mediums who charge for spiritual consultations should be avoided. The need to deliver results may skew findings of spontaneous mediumistic experiences. It is important to evaluate any interfaces between mediumship and other phenomena self-produced by the expectation of 'convincing' results, dissociative disorders, other psychiatric conditions, or charlatanism if we are to avoid epistemology in this nascent field being contaminated by dubious results. Therefore methods for controlling these variables should be developed.

Helping volunteers to feel at ease

In both cases, subjects did their writing in a quiet and dimly lit sideroom at the neuroimaging lab. We asked them to psychograph in the same manner as in their regular activities as mediums. All followed the same procedure: they sat comfortably, closed their eyes, concentrated, and said a prayer. In general, they entered trance state in a few minutes, took up a pencil, and started writing. The mediums reported going into the trance state easily and quietly. To ensure that they feel comfortable and that the phenomenon is manifested as if they were 'at home', a qualitative interview beforehand should ask them about conditions needed for the phenomenon to occur. Mediums in general like to take part in research but but being 'tested' would certainly be uncomfortable. Researchers should establish friendly relations, be respectful of suggestions, and show that their opinions are important. In our own study, for example, volunteers asked for spiritual support from fellow mediums, some of whom were nearby and others far from the person undergoing neuroimaging. We should minimize expectations and fears of mediums not performing well on tasks. Any erroneous notions participants may have about researchers' expectations should be deconstructed. Let them see that researchers will welcome the mediumistic experience just as it is. It is also crucial to familiarize volunteers with potential triggers of anxiety or other disturbing effects (hospital context, neuroimaging technology, blood samples, injections etc.). Start with the more confident volunteers, who will naturally convey their ease or peace of mind to the others.

Objective evaluation by blind experts

Mediums themselves report that different types of spiritual communication may occur separately or simultaneously. The volunteers we studied[22] reported their principal mediumistic manifestations as follows: full trance/embodiment (feeling the spirit in their own body); psychophony (verbally expressing what a spirit communicates); clairaudience (hearing spirits or the noise they produce); clairvoyance (seeing spirits); psychography (writing content that a spirit communicates).

Future studies should consider the possibility of expert external evaluators blindly assessing aspects of mediumistic experience, as well as the quality of the content produced in this state (expressing in words, writings, paintings etc.), in addition to the content

Table 1. Comparison of neurofunctional imaging technologies[53]

Technology	Database	Spatial resolution	Temporal resolution	Advantages	Limitations
Positron Emission Tomography (PET)	Measures of cerebral blood flow alterations and metabolic energy caused by neuronal activity (measured by radioactivity)	4.5-15 mm	Seconds to minutes	• Examination with temporal dynamics (variations measured during the task) • Good spatial location in active regions • Data may be analyzed qualitatively and quantitatively • Coverage of activity throughout the brain • Data may be merged into CT or MRI • Use of different markers for metabolic studies • May be used to measure various abnormalities in encephalic functions • Dim light	• Invasive (requires radioisotopic marker injection) • Experiments cannot be repeated often in a short period of time • Subjects must not move (prone to motion artifacts) • Does not acquire anatomy • Limited resolution • Markers unstable, short half-life (minutes) • Cyclotron must be near tomography camera
Single Photon Emission Tomography (SPECT)	Measures alterations in cerebral blood flow and metabolism due to neural activity at a given point in time (measured by radioactivity)	8-15 mm	Single image, 3-5 minutes	• Gamma camera acquisition after injection marker (reduces motion artifacts) • Allows choice of location for volunteer (*e.g.* therapeutic setting, quiet room with dim lighting) • Data may be analyzed qualitatively and quantitatively • Coverage of activity throughout the brain • Data may be merged into CT or MRI • Markers more stable with longer half-life (4 -6h, ECD and HMPAO) • Low cost and greater availability of method • Tenuous, silent examination	• Invasive (requires radioisotopic marker injection) • Experiments cannot be repeated often in a short period of time • Limited resolution • Does not acquire anatomy • Not dynamic (measures a single period of continuous tasks) • Restricted to studies with non-variable tasks
Functional Magnetic Resonance Imaging (fMRI)	Measures alterations in cerebral blood flow and oxygenation in the brain that occur with neuronal activity	Less than 1 mm to 3 mm	30 ms to 1 s	• High spatial and temporal resolution • MR equipment may be used • Allows direct correlation between function and underlying anatomy • Non-invasive (no radiation) • Coverage of activity throughout the brain • Several paradigms may be used with a simple test • Allows repeated studies of individuals in a short period of time	• Does not measure neural activity directly • Signal strength varies, even with constant intensity stimuli • May give negatives and false positives (BOLD effect due to excitatory and inhibitory synapses) • EPI Noise (80 db average) during acquisition • Individuals have to cooperate during lateralization studies • Limited to interictal studies (prone to motion artifacts) • High cost • Individuals with pacemakers or magnetic implants must be excluded
Spectroscopic Magnetic Resonance (MRS)	Measures alterations in concentration of metabolism due to neuronal activity (measuring through RF signals)	Relatively poor (1.7 cm^3)	Seconds to minutes	• Non-invasive metabolic studies • High chemical specificity • Does not require sophisticated computer utilities (however, data and subsequent analysis require systems other than those used for imaging studies)	• Does not measure neural activity directly • Spatial resolution most frequent treated by chemical information (low resolution) • Can detect one molecule at millimolar concentrations • Limited to interictal studies (prone to motion artifacts) • Individuals with pacemakers or magnetic implants should be excluded • High cost
Magnetoencephalography (MEG)	Measures magnetic field generated by neuronal activity	1-8 mm	Ms	• Non-invasive • Direct measurements of physiological regions of interest • Increased potential accuracy *vs.* EEG • High temporal resolution of cerebral dynamic • Good spatial-temporal combination • Tenuous, silent examination	• High cost (requires magnetically shielded room) • Difficulty for spatial location (errors in mathematical models) • Limitation for interictal data (prone to motion artifacts) • Limited depth and orientation (sensitive only to superficial and tangential sources) • Slow acquisition of data • Magnetic artifacts in cases of dental prostheses, surgical steel, pacemakers or other implants

Table 2. Neuroimaging studies involving religious experiences

Study	Method	Subjects	Paradigm	Brain activity Decrease (↓) Increase (↑)
Azari *et al.*, 2001[59]	PET	6 Fundamentalist Christians	Religious experience	↑ DLPFC, dorsomedial frontal and medial parietal cortex
Newberg *et al.*, 2003[55]	SPECT	8 Franciscan nuns	Prayer	↑ PFC, inferior frontal lobes and inferior parietal lobes
Beauregard *et al.*, 2006[57]	fMRI	14 Carmelite nuns	Sense of union with God	↑ RL medial orbitofrontal cortex, R middle temporal cortex, RL inferior and superior parietal lobules, RL caudate, L medial PFC, L ACC, L insula, L brainstem, striate visual cortex
Newberg *et al.*, 2006[56]	SPECT	6 Charismatic prayers	Glossolalia	↑ L caudate ↓ DLPFC, L superior parietal
Beauregard *et al.*, 2009[64]	fMRI	15 patients with NDE	Meditation on "being of light"	↑ R brainstem, R orbitofrontal cortex, R PFC, R superior parietal lobule, L temporal lobe, L insula, and L parahippocampus
Harris *et al.*, 2009[62]	fMRI	15 believers/15 non-believers	Belief judgments of "true" *vs.* "false"	Belief associated with ↑activity in the ventromedial PFC; religious thinking associated with brain regions that govern emotion, self-representation, and cognitive conflict; ordinary thinking associated with memory retrieval networks
Ge et al., 2009[63]	fMRI	16 Christians/16 non-believers	Trait judgments about Jesus	Functional connectivity between MPFC and posterior parietal lobe, differentiated trait judgments of political leaders and the self but not between Jesus and the self
De Araujo *et al.*, 2012[61]	fMRI	9 Ayahuasca users	Effect of Ayahuasca	↑ occipital, temporal, and frontal areas
Peres *et al.*, 2012[22]	SPECT	10 psychographers	Psychography *vs.* normal writing	↓ L culmen, L hippocampus, L inferior occipital gyrus, L anterior cingulate, R superior temporal gyrus and R precentral gyrus

PET: positron emission tomography; SPECT: single photon emission computed tomography; fMRI: functional magnetic resonance imaging; ACC: anterior cingulate cortex; PFC: prefrontal cortex; DLPFC: dorsolateral prefrontal cortex; R: right; L: left.

generated in habitual state of consciousness (out of trance) and by control groups. Moreover, a careful evaluation of the phenomenological experience investigated by neuroimaging may favor more accurate correlation between first-person (phenomenological) and third-person experience (brain activity observed). Complexity scores – assessed blindly by experts – for content produced during trance or relevant aspects of experience may be used as covariates in statistical analyzes, and our own study led to interesting results in this respect. An expert in Portuguese language blindly scored texts produced by mediums during the two tasks in our study. A linear correlation analysis comparing complexity scores for written content with altered CBF in areas related to the state of psychography (left culmen, left hippocampus, left inferior occipital gyrus, left anterior cingulate, superior right gyrus, temporal gyrus and right precentral gyrus), showed a trend toward inverse correlation in that higher levels of complexity were associated with gradually decreasing CBF in each region. The trend for inverse correlation found in our study, when taking into account the complexity of the psychographed content, calls for further discussion and research based on insightful hypotheses.

Challenging discussions

Good research may be undermined by inappropriate discussion. Data should be examined cautiously and respectfully with an open-minded approach to avoid recurring bias simply repeating the eternal return of promissory materialism[46]. Our *a priori* hypothesis was not confirmed since the results showed significant changes in blood flow in several brain areas during psychography compared with writing in a non-trance state. In addition, the experienced mediums writing in a state of dissociative trance showed significantly lower rCBF than when writing normally in the control condition.

Volunteers reported that trance involved a "state of mental relaxation", which may explain lower overall brain activity; but the fact that they composed complex content in a state of dissociative trance suggests that they were not merely relaxed. The results do not suggest simulation or fraud, which have been offered as explanations for mediumship. Neural circuits related to planning would presumably be recruited to compose written content if individuals were intentionally simulating.

The decreased activity in the temporal cortex, precentral gyrus, hippocampus and anterior cingulate in experienced mediums also supports their subjective reports that they were not aware of the content they were writing during psychography, which involved ethical or spiritual matters and the importance of joining science with spirituality. The mediums reported that texts were psychographed from communicating spirits and did not attribute them to their own brains, which is also a plausible hypothesis.

Our own findings maybe discussed in relation to neurofunctional studies of other altered states such as hypnotic[65] and meditative states[66], which are phenomenologically distinct expressions of mediumistic expression and therefore not directly comparable. Moreover, as in the case of meditation, the idea that hypnosis reflects a dissociative state is still controversial[67]. Musical improvisation, in which decreased activity in attentional circuits may have involved training for inhibition of attention, favors the emergence of creativity[68,69]. Again, in relation to creativity, a recent study showed that by reducing frontal lobe activity, alcohol appears to boost creativity or perhaps decrease self-criticism[70]. However, musical improvisation states – with marked involvement of motor memory – and alcohol consumption are very specific and distinct from psychography, which involves writing intelligible content with ethical messages rather than improvising content, so they cannot be compared. On the other hand, studies of cognitive expertise involving planning neural circuits showed more activity during tasks performed by experts[71]. For example, like planning refined written content, playing chess involves many aspects of cognition and requires sophisticated problem solving skills. Chess specialists showed accentuated activity in the posterior cingulate, orbitofrontal cortex and right temporal cortex compared to beginners[72]. Neurofunctionnal studies of arithmetical prodigies and abacus users suggest that experts expressed higher levels of brain activity on a number of different pathways, such as planning and attentional circuits[73]. However, further research is required to meticulously compare psychography with other mediumistic states and accurately elucidate any relationship between circuits associated with creativity and attention versus depth, intensity, and complexity of content produced during mediumistic states. It would be useful if we could observe the complexity of mediumistic expressions and their increased or decreased activity in related attentional circuits,

so we hope that good functional designs will be developed in this direction.

Although volunteers in our study reported having auditory hallucinations, personality changes and other dissociative behaviors, structured clinical interviews excluded psychiatric disorders. As we noted in our study, despite several similarities with brain activation reported for schizophrenic patients, none of the mediums had any mental disorder[22]. These findings underscore the importance of future research using precise criteria to distinguish healthy from pathological dissociative expressions within the scope of mediumship.

Limitations

An embryonic line of research may meet with difficulties in terms of discussing relations between findings obtained from early neuroscientific studies and research published on other states of consciousness that are phenomenologically distinct from expressions of mediumship. Therefore, researches should ensure that similar mediumistic conditions are directly comparable, including controls (tasks and subjects) chosen for pertinence to investigate topics such as: the hypothesis of spiritual communicability, criteria used to distinguish between healthy and pathological dissociative expressions in the context of mediumship, and relationships/differences between schizophrenia and mediumship.

Penfield's electrical stimulation of brains of conscious individuals in order to map cortical functions led to very important contributions such as the 'Penfield homunculus' that related brain structures to specific functions[74]. Penfield's *The Mystery of the Mind* pondered his long years of research and suggested that mind existed separately from the brain but was closely related. "There is no place in the cerebral cortex where electrical stimulation will cause a patient to decide"[75]. Of course, determining functions in isolated regions was a first step for the neurosciences on the road toward coherent understanding of all cerebral activity. Even such a first step of recognizing and limiting specific functions of each part of its structure is not easy, and perhaps not even feasible considering mental expressions and consciousness, because of variables that are as yet little understood. For example, imaginary listening and visualizing conditions also obeyed neural reciprocities similar to actually hearing and seeing the same events[76,77]. Volunteer musicians asked to imagine a certain melody activated neural circuits as if in a situation in which they were hearing the same melody through headphones. The authors gave their article the suggestive title "Sound of silence activates auditory cortex"[76]. The fact that stimulating specific brain regions causes certain experiences does not mean that the ultimate origin of experience is in the brain. Neural syntax seems to combine isolated structures such as letters composing countless words, sentences, and paragraphs in different languages and favoring translation of myriad human experiences, although many of them might be indescribable in this cerebral semantics. While neuroscience has made great progress in discovering the functions of brain regions, little is known of the dynamic patterns of translation, connectivity, and flows of mental information in the brain. Therefore, it would be a mistake to identify a region or brain circuit involved in mediumistic experiences and conclude that these neural correlates are the ultimate causes of such experiences. The same experience may have different causes. Moreira-Almeida and Santos[3] suggest that tachycardia may have a wide range of causes such as anxiety, heart failure, exertion, cocaine, etc. Therefore, finding the cause of a tachycardia episode in a particular patient does not mean we have found the cause of all such episodes, for this patient or for all humans. This seems to be the case for similar hallucinatory experiences reported by mediums[3,22].

Cognitive neuroscience usually develops hypotheses to explain phenomena based on measurable activity in space (brain structures and circuits) and time (acquisition of single images as in the case of the SPECT method or acquisitions in continuous temporal sequences as in the case of PET and fMRI methods). Due to the influence of promissory materialism, some neuroscientists may be looking in the wrong direction on searching for activated or lit brain regions during supposed spiritual communication, instead of observing the attenuation of neural activities expected to generate information – sometimes complex – arising from mediumistic trance. As well as considering increased and decreased neural activity in mediumistic manifestations, we should carefully plan control tasks and groups using statistical analysis to examine alleged spiritual communicability.

The low temporal and spatial resolution of current neuroimaging methods restricts our ability to capture complex neural filigrane and we are unable to tackle the complexity of cerebral syntax with our present technology and knowledge. Future multimodal methods, which combine advantages from different neuroimaging techniques[53], will examine neural correlates, be they functional, structural, neurochemical or molecular, thus adding to growing comprehension of how information circulates in the brain in accordance with the mental experiences that seem to be translated[78,79].

Conclusion

The present article covers some key mind-brain debates, neurofunctional studies of religious experiences, as well as certain methodological challenges and limitations we consider may be of use when formulating neurofunctional designs for research on mediumship and spiritual phenomena. Most neuroimaging studies of religious experiences do not focus specifically on "spiritual communication", but precisely this issue may be relevant for science. Our preliminary results[22] suggest continuing and extending this nascent and fruitful line of research. Since comprehension of neural correlates involved in mediumship is still at an early stage, we emphasize that these findings call for further replication and explanatory hypotheses. This new line of research must go hand in hand with formulations of hypotheses to cover a wide range of phenomena involved in mediumship and alleged spiritual manifestations. Therefore, we consider that further studies with neuroimaging methods should focus on mediumship, so we call on our neuroscientist colleagues to collaborate and invest in this important line of research in order to improve the consensus comprehension of consciousness, spiritual experiences and its relations with the brain.

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