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DOES NEUROIMAGING OF SUGGESTION ELUCIDATE HYPNOTIC TRANCE?[1]

Amir Raz[2]

McGill University, Montréal, Quebec, Canada

Abstract: Contemporary studies in the cognitive neuroscience of attention and suggestion shed new light on the underlying neural mechanisms that operationalize these effects. Without adhering to important caveats inherent to imaging of the living human brain, however, findings from brain imaging studies may enthrall more than explain. Scholars, practitioners, professionals, and consumers must realize that the influence words exert on focal brain activity is measurable but that these measurements are often difficult to interpret. While recent brain imaging research increasingly incorporates variations of suggestion and hypnosis, correlating overarching hypnotic experiences with specific brain substrates remains tenuous. This article elucidates the mounting role of cognitive neuroscience, including the relative merits and intrinsic limitations of neuroimaging, in better contextualizing trance-like concepts.

The hypnosis literature is burgeoning with brain imaging techniques borrowed from cognitive neuroscience. Researchers, including myself (Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006), have shown in the laboratory that phenomena typically associated with the experience of hypnosis, such as hallucinations and regulation of pain, can follow suggestions even in the absence of hypnosis. At least some scholars consequently argue that neither trance nor a discrete state unique to hypnosis is necessary to instigate these phenomena. Most of these researchers maintain that hypnosis is a form of common wakefulness—one procedure, out of many, to enhance compliance with suggestion. On the other hand, researchers—again, including myself (Raz, 2004; Raz & Buhle, 2006; Raz, Fan, & Posner, 2005)—have managed to provide data that some scholars interpret as evidence supporting a distinctive physiological marker of trance or altered state of consciousness

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[2]Address correspondence to Amir Raz, McGill University and SMBD Jewish General Hospital, Lady Davis Institute for Medical Research, Institute of Community and Family Psychiatry, 4333 Cote Ste. Catherine Road, Montréal, QC H3T 1E4, Canada. E-mail: amir.raz@mcgill.ca

unique to hypnosis or to hypnotic suggestion. Reconciling these two accounts is indeed difficult, especially because my research, paradoxically, seems to support both views. This confusion, however, is a great opportunity to do good research and advance the field rather than carp and debate with incipient acrimony (Raz, 2007). Whether hypnotic suggestibility is a function of factors such as expectation, motivation, belief, and imagination or a deterministic brain wiring indexable by specific biology is an issue that continues to both intrigue me and guide my research.

Suggestion is Powerful

The emerging science of suggestion is gradually joining forces with the established science of attention. Suggestion and attention are central themes in cognitive science (Raz & Buhle, 2006). They reify the links between brain and behavior and marry psychology with the techniques of neuroscience (Posner & Rothbart, 2007b). Experimental findings propose that suggestion and attention influence cognition, affect, thought, and action (Posner & Rothbart, 2005, 2007a). In addition, studies involving brain imaging and genetics begin to unravel both the neural underpinnings of suggestion and its underlying substrates (Posner, Rothbart, & Sheese, 2007; Raz, 2008). The bulk of the evidence supports the idea that attention and suggestion form intersecting organ systems (Raz, 2005). Indeed, these psychological constructs draw on circumscribed and largely independent brain circuitry, functional neuroanatomy, chemical modulators, and cellular structures (Fernandez-Duque & Posner, 2001; Posner & Fan, 2004; Raz, 2006; Raz, Lamar, Buhle, Kane, & Peterson, 2007). Thus, the relationship between attention and suggestion has been affirmed theoretically as well as empirically (Raz, 2004, 2005, 2006, 2007, 2008; Raz & Buhle, 2006; Raz, Lamar, et al., 2007).

Multiple accounts corroborate the involvement of psychological parameters, including suggestion and expectation, in the modulation of biological processes (Harrington, 2008). The literature is fraught, however, with uncritical accounts of suggestion. In one cancer patient, for example, suggestion seemed to trigger dramatic tumor shrinkage and miraculous remission while a subsequent suggestion led to abrupt death (Klopfer, 1957). Beyond anecdotes, many compelling assays demonstrate the power of suggestion (Brown, 1985; Gauld, 1992). Believing that they are ingesting alcohol, for example, participants in psychology experiments displayed the symptoms of alcohol intoxication even when drinking nonalcoholic beverages (Marlatt & Rohsenow, 1981). Treated as if they were hypervigilant pilots, Harvard undergraduates outperformed "regular" Harvard control students on visual acuity tasks, including a "routine eye check-up" (Langer, 1989).

Although visual acuity hardly improved, students in an experimental condition were better than controls at identifying small targets on a screen (cf. Raz, Marinoff, Landzberg, & Guyton, 2004; Raz, Marinoff, Zephrani, Schweizer, & Posner, 2004; Raz, Zephrani, Schweizer, & Marinoff, 2004). In another study, researchers found that by repeatedly suggesting to adults that they had become ill from eating particular foods in childhood, participants consequently avoided these foods (Bernstein, Laney, Morris, & Loftus, 2005). Taken together, such studies provide a sampling of the diverse influence suggestion can wield on physical and mental experience.

A Brief History and Culture of Suggestion

Individuals under the influence of a charismatic authority can have bodily experiences that many professionals consider “all in the head.” The King’s Touch (KT), for example, refers to the belief that illness could be cured by the touch of a divinely inspired leader (Jacob, 1974). Whereas KT is more difficult to trace down in other cultures, western European history identifies Edward the Confessor as the first ruler who touched to cure (Alexander & Selesnick, 1966). While practitioners of KT probably practiced a layman’s form of psychotherapy that had previously belonged to members of the ruling class (Bromberg, 1954), modern science often dismisses KT as preposterous. One Nobel Laureate, for example, claimed that chicken soup might be a more credible source of healing than KT, reasoning that ingesting soup might have chemical effects on the body, whereas the symbolic act of KT seems unlikely to have a meaningful influence (e.g., on bacteria) (Weinberg, 1992). Suggestion, however, entails more than words and can bring about very real physiological change—KT may be worth another look (cf. Harrington, 2008; Kosslyn, Thompson, Costantini-Ferrando, Alpert, & Spiegel, 2000; Rainville et al., 1999; Raz & Buhle, 2006; Raz et al., 2005; Szechtman, Woody, Bowers, & Nahmias, 1998).

People seem to experience specific diseases differently from how they had experienced the same diseases years ago (Harrington, 2008). In the same way that universities or political systems have histories, diseases too go through a process of cultural evolution. Compelling evidence demonstrates, for example, that the way we experience stress today is probably a product of the post-World War II era. Before that time, people responded to the vicissitudes of life with different symptomatology, such as fatigue, exhaustion, and photophobia. Instead of being overwrought, people would retire to bed early. Since then, however, we have replaced “bad nerves” with “stress” and have adopted a new way to experience it. So pervasive is this transformation in our culture that we apply it indiscriminately to fictional characters as well as celebrities. For example, Heidi—Johanna Spyri's literary heroine of Swiss literature whose trip back to nature reverses her failing health and bouts of sleepwalking—and young Teddy Roosevelt—whose hunting and fishing excursions brought him from bad nerves to strength—show that past remedies were different from those we use today.

Scholarly illustrations of cultural suggestions abound. For example, menopausal women in Japan rarely experience the hot flashes and night sweats that are widespread among the older women of North America. One potential explanation for this transcultural difference has to do with the way societies view mature women. In contrast to North America, Japanese society seldom construes female aging as a sign of diminished worth, and some scholars argue that vasomotor symptoms differ according to the suggestions of these separate cultures (Locke, 1993, 1998). Lactase, the enzyme necessary to digest milk, provides another example that culture is a coconstruct of biology. While the majority of adult humans rarely produce lactase, descendants of populations that domesticated cattle and used milk as a central food source are more likely to carry a genetic variation allowing lactase to persist into adulthood (Beja-Pereira et al., 2003; Durham, 1991). As well, clinical examples include culturally specific instances, such as forms of panic among Vietnamese and Cambodian patients in the United States (Hinton et al., 2007; Hinton, Um, & Ba, 2001). Thus, disparate beliefs and expectations likely evoke particular behaviors and experiences. The effect culture has on behavior is consistent with our modern concept of suggestion.

Perhaps the apotheosis of this type of cultural suggestion comes from the history of hypnosis. The mental and physiological experiences that comprise hypnosis have morphed in ways that reflect changing social expectations and mores (Gauld, 1992). Eighteenth-century patients of Anton Mesmer, for example, felt animal magnetism racing through their bodies. Patients of Amand-Marie-Jacques de Chastenet (Marquis de Puységur), however, replaced these symptoms by providing evidence of having access to heightened, even supernatural, mental abilities. Better yet, by the second half of the 19th century, these occult-like characteristics disappeared, and instead hypnosis had become a quasipathological phenomenon, with specific physiological profiles such as catalepsy, lethargy, and somnambulism. Thus, bodies might have culture too; our mental processes seem to have a history (Harrington, 2008).

Hypnosis Research and the Perils of Neuroimaging

Hardly any advance in neuroscience has garnered as much public interest as imaging of the living human brain. To see the crisp images of the human brain in action seems to mesmerize the masses, including many hypnosis scholars. For example, members of our community have proposed functional magnetic resonance imaging (fMRI) studies to capture trance phenomena. After all, fMRI can unravel the effect that suggestions can invoke by examining the influence of words on the workings of the mind (Raz & Shapiro, 2002; Shapiro, 2004). As a case in point, using hypnotic suggestion as an experimental intervention, my colleagues and I have conducted multiple imaging studies showing how specific suggestions correlate with focal brain changes (Raz, 2004; Raz & Buhle, 2006; Raz et al., 2005). For example, suggestion has been shown to influence neural processing in the domains of color vision (Kosslyn et al., 2000), audition (Szechtman et al., 1998), pain (Kong, Kaptchuk, Polich, Kirsch, & Gollub, 2007; Rainville et al., 1999), and word-reading (Casiglia et al., 2010; Raz et al., 2005; Raz, Moreno-Iniguez, Martin, & Zhu, 2007; Raz, Shapiro, Fan, & Posner, 2002). Thus, from parlor magic and hysteria-inspired psychiatry all the way to contemporary brain research, suggestion has made its way into empirical imaging. When it comes to neuroscience, however, the hypnosis community may benefit from a sober examination of the prospects of brain imaging. Before examining results from any imaging excursion heading into one of the cornerstones of the hypnosis debate, our community may want to ruminate about what will likely transpire.

It takes a great deal of computer processing and human judgment to get from blood oxygen levels to a snapshot of altered consciousness in the brain. Increasingly ubiquitous, fMRI is a noninvasive brain measurement technology, opening a window into the neurological underpinnings of behavior. Technologies such as fMRI entice researchers to submit higher brain functions, including morality (Greene, Nystrom, Engell, Darley, & Cohen, 2004), to scientific scrutiny. The images harbored by such efforts, however, may enthrall more than explain (McCabe & Castel, 2008). This type of "neurorealism" speciously leads individuals to believe that images of brain activity make a behavioral observation more veridical (Racine, Bar-Ilan, & Illes, 2006b). Consequently, media coverage frequently oversimplifies research findings and marginalizes caveats (Racine, Bar-Ilan, & Illes, 2006a). In November 2007, for example, the *New York Times* (*NYT*) published an op-ed column describing fMRI findings from undecided voters who viewed photographs and videos of the major candidates in the last U.S. presidential election (Iacoboni et al., 2007). According to the study's authors, the findings revealed "some voter impressions on which this election may well turn" (Iacoboni et al., 2007, p. 1). A later editorial in *Nature* lambasted studies that simply place individuals in fMRI scanners and then come up with elaborate stories describing the results ("Mind games," 2007). Interesting concoctions of neuroscience to coat political clichés and female brains have already found their way to print

(Brizendine, 2006; Westen, 2007), hence as the use of fMRI becomes more commonplace, consumers of neuroimaging may benefit from a measure of rigor (Kriegeskorte, Simmons, Bellgowan, & Baker, 2009).

fMRI signals are weak and engulfed by much "noise" in the form of false signals. Moreover, the signals in fMRI studies are often so weak that researchers have to stimulate a person's brain time and again to discern any pattern. When researchers want to discover which areas of the brain respond to faces, for example, they typically present many faces in order to detect an increase in neural activity in a specific brain area. Thereafter, they repeat the experiment on a dozen or more additional individuals to ascertain that the same brain areas consistently light up across people. In many cases, this outcome is unwarranted even though face recognition is a relatively robust process compared with, say, hypnotic hallucinations. Thus, hypnosis researchers should be careful to embrace fMRI findings identifying higher brain functions that appear to index trance constructs.

fMRI studies frequently produce billions of data points—most of them sheer noise—wherein one can find coincidental patterns (Kriegeskorte et al., 2009). As well, many fMRI studies dip into the same data twice: first to pick out which parts of the brain are responding and, second, to measure the response strength. This practice of double dipping is incorrect statistically and results in findings that appear stronger than they actually are (Vul, Harris, Winkielman, & Pashler, 2009a, 2009b). Hence, onlookers must exercise great caution when beholding the casting of messy data into tidy images.

Rendering trance concepts amenable to neuroscience research calls for even keener appreciation of the limitations of neuroimaging. As 17 prominent cognitive neuroscientists pointed out in a collective reply to the *NYT* op-ed piece, one of the core shortcomings of a naïve fMRI approach hinges on reverse inferences, inferring a specific mental state from the activation of a particular brain region (Aron et al., 2007). For example, anxiety involves fMRI signal changes in the amygdala, but so do many other things, including intense smells and sexually explicit images. The blunder of "reverse inference" is widespread and many neuroimagers, including signatories to the *NYT* rebuking response, have "sinned" by reverse inferencing in an attempt to understand how brain mechanisms subserve mental processes (Poldrack & Wagner, 2004). Because cognitive neuroscience is a relatively new field of scientific inquiry, however, some of the same researchers who have initially advocated the idea of reverse inferences have grown considerably more skeptical of it in recent time (Poldrack, 2006). Although reverse inferences may still be useful in specific situations, cumulative analyses over the past few years have resulted in marked disillusionment regarding many of the reverse inferences presented in the literature. Thus, past support for reverse inferences has taken a turn against it.

Reverse inferences are particularly common in newer fields such as social cognitive neuroscience and neuroeconomics, not to mention neurohypnosis; fields in which researchers are still trying to identify the cognitive processes underlying the behaviors they study. One study, for example, used fMRI to investigate the neural underpinnings of individuals who were mulling over moral dilemmas (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). Brain areas with fMRI signal changes included regions that had been linked to "emotional" and "rational" cognitive processes in previous studies. Researchers thus concluded that these two types of processes are active, to different degrees, in different types of moral judgments. The rigor of such arguments, however, depends on the evidence that a focal brain area instigates a particular mental process. It so happens that at least some of the emotional brain regions in the morality study have also been associated with memory and with language. It is curious that such caveats typically escape mention (Miller, 2008).

Using results from brain imaging as "probabilistic markers of brain states" may represent a viable approach, but we must scrutinize the probabilities. Testing these odds on real data revealed that while engagement of an individual region did provide some statistical information regarding the engagement of a mental process, the added information was relatively weak (Poldrack, 2006). Cognitive neuroscience may ultimately find ways to predict mental states using brain imaging data. Even then, rather than surfacing from localized activity in a focal brain region, such predictions will likely result from both subtle activation patterns and the coordinated activity across many brain regions.

Using specific reverse inferences (e.g., the association of fMRI signal change in the amygdala with anxiety) is a function of previous publications. The distribution of terms in the literature, however, is a function of past theories that have driven publications in particular directions and that may hardly reflect current perspectives. For example, the scientific literature contains many more citations for "amygdala and anxiety" than for "amygdala and happiness." This difference, however, is a reflection of roughly 30 years of research investigating the association between anxiety and amygdala activity, whereas only recently have researchers begun to examine the role of the amygdala in positive emotional responses. Thus, to surmise that amygdala activity is a strong prognostic of negative emotion may be misleading.

fMRI has transformed neuroscience in fewer than two decades. Many studies, however, including some of those that garner the most attention in the popular and trade press, shed little light on the neural mechanisms of human cognition, affect, thought, and action. Researchers attempt to confront the limitations of fMRI by conducting experiments that match human fMRI data with analogous fMRI and electrophysiological recordings of neural activity in nonhuman primates. The general idea is to follow up on the human findings by identifying equivalent regions of the monkey brain using fMRI and then recording the activity of individual neurons in those locations using microelectrodes. In some cases, single-neuron recordings have confirmed fMRI findings (Tsao, Freiwald, Tootell, & Livingstone, 2006). Whereas the parallel human-monkey approach represents an admirable albeit time-intensive paradigm, one of its main drawbacks is the difficulty in applying it to study many types of human cognition and social interaction, including hypnosis.

Comely fMRI-generated images may seduce the general public, but even neuroscientists seem to fall for them and overlook the limitations of neuroimaging. One constraint is the narrow sliver of the human experience that researchers can capture when a person has to keep still inside a scanner. Another limitation pertains to resolution: Using fMRI to measure nuanced neural activity is akin to observing ocean currents to learn about the properties of water drops. fMRI can only detect large-scale activities; generalizations to subtle local effects is speculative and tenuous at best. In addition, with standard fMRI equipment, even the atomic volume-pixel unit of imaging (i.e., the voxel) typically comprises millions of neurons. Neurons can fire hundreds of impulses per second, however, and the fMRI signal—triggered by an increase in oxygenated blood—builds incrementally and peaks after several seconds, not instantaneously. Thus, fMRI is an indirect, crude tool for investigating how neuronal ensembles "compute" cognition and behavior. fMRI can be helpful in guiding where something is happening in the brain, but it is considerably more difficult to use fMRI to elucidate mechanisms.

The Promise of Neuroimaging

A very different approach to overcoming some of fMRI's constraints comes from new analysis tools borrowed from machine-learning research. In a standard fMRI study, neuroscientists average together the fMRI activation from neighboring voxels. While averaging makes it easier to detect differences between experimental conditions, this technique follows the assumption that neurons from different voxels all behave the same way. This assumption, however, is extremely unlikely. Instead, it is possible to use statistical tools—multivariate pattern classifiers—to take a finer grained look at brain activity that considers patterns of activation across many individual voxels without averaging. These methods shift the focus from trying to identify the specific brain regions activated during a particular task to trying to identify how the brain processes germane information.

An early demonstration of this statistical approach came from a neuroimaging study that presented participants with hundreds of images of faces, cats, houses, and scissors (Haxby et al., 2001). The investigators identified statistically distinct brain activity patterns that each type of object elicited. fMRI activation in the primary visual cortex made it possible to determine the orientation of lines a participant was viewing, a feat previously thought impossible because neurons that share a preference for lines of a particular orientation pack into columns narrower than a voxel (Op de Beeck, Haushofer, & Kanwisher, 2008; Tong, 2003). A recent session in the Cognitive Neuroscience Society annual conference presented a variety of new findings illustrating how this new analysis of fMRI data can reveal information processing in the brain that would be overlooked by conventional analyses (Raizada, 2008). Hence, rather than looking at whether a specific brain region is active, researchers are beginning to focus on whether the activity in many different voxels can predict what people are experiencing. In other words, instead of inferring that a spider induces anxiety, researchers could collect patterns of brain activity evoked by known anxiety inducers (e.g., images of snakes, accidents about to happen, and presurgical situations) and see whether the spider pattern forms a statistical match. While it may well be that such classifiers will help rescue fMRI research from the logical perils of reverse inference, even with the promise of these new tools fMRI remains limited to revealing correlations between cognitive processes and activity in the brain.

fMRI may be most effective when people view it as one tool in a toolbox (i.e., by employing converging techniques and evidence). Increasingly, neuroscientists are using fMRI and related methods to investigate the connectivity between different brain regions involved in cognitive functions such as language and memory. One fMRI approach is to identify brain regions whose activity is synchronized when subjects perform a given task. In some cases, researchers use diffusion tensor imaging (DTI) to further determine whether physical connections link those areas that fire together. A relatively new MRI method, DTI provides a way to visualize the axon tracts that connect regions. Other researchers are trying to establish causal links between brain and behavior. Having linked a brain region to a particular behavior using fMRI, for example, some researchers are following up with transcranial magnetic stimulation (TMS) experiments. If the behavior then changes, the brain region likely plays a role in controlling it.

Suggestion seems to be a promising site upon which neuroscience and hypnosis can, successfully, come together. In particular, neuroimaging studies on hypnotic paralysis may elucidate lines of difference behind subjective and intentional mechanisms (Halligan, Athwal, Oakley, & Frackowiak, 2000; Ward, Oakley, Frackowiak, & Halligan, 2003), if such lines do exist (Cojan et al., 2009).

Conclusion

Karl Popper's "falsifiability criterion" posits that a theory is truly scientific if it retains the possibility of showing itself false. The history of science reveals, however, many theories that were unfalsifiable initially, which we can label as two types. Theories of the first type lacked falsifiability because they were insufficiently operationalized in terms of measurable variables (e.g., psychoanalysis), whereas theories of the second type were unfalsifiable because they were underdeveloped. Those latter theories, nonetheless, served a valuable heuristic purpose in generating a large body of useful research from which new theories and empirical findings could evolve. Confirmations, extensions, and revisions to a theory in support of a trance state will likely permit its transition from the first to the second type of theories. This shift will afford more testable predictions as additional research increasingly draws on new methodologies, including advances in default mode processing, that is, nontask-related mental activity and task-unrelated thoughts (Mason et al., 2007; McGeown, Mazzoni, Venneri, & Kirsch, 2009; McKiernan, D'Angelo, Kaufman, & Binder, 2006), transcranial magnetic stimulation, electroencephalography, and fMRI. As neuroimaging studies begin to elucidate the neural correlates of culture (Han & Northoff, 2008), converging findings to unlock the operationaliztion of suggestion (Oakley & Halligan, 2009) and motivation (Kouneiher, Charron, & Koechlin, 2009) will likely pave the road to a more scientific understanding of psychosocial factors. A biological marker for major depression still eludes us, however, and a distinctive physiology for trance may be even less corporeal. Until converging, consistent, replicable findings materialize, therefore, we must also heed a sociocognitive perspective.

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Kann das Neuroimaging der Suggestion die hypnotische Trance aufklären?

Amir Raz

Abstract: Aktuelle Studien innerhalb der kognitiven Neurowissenschaften der Aufmerksamkeit und der Suggestion werfen ein neues Licht auf die zugrunde liegenden neuronalen Mechanismen, die die Effekte operationalisieren. Ohne eine gewisse Vorsicht, die bei der Bildgebung am menschlichen Gehirn stets geboten sein sollte, können Erkenntnisse aus bildgebenden Studien jedoch vielmehr begeistern als tatsächlich erklären. Wissenschaftler, Praktiker, Fachleute und Verbraucher müssen erkennen, dass der Einfluss, den Worte auf die fokale Hirnaktivität ausüben, zwar messbar ist, diese Messungen jedoch oft sehr schwierig zu interpretieren sind. Während die jüngste bildgebende Forschung zunehmend Suggestion und Hypnose variiert, bleiben Korrelationen umfassender hypnotischer Erfahrungen mit bestimmten Substraten im Gehirn leider dürftig. Dieses Papier beleuchtet die zunehmende Rolle der kognitiven Neurowissenschaften bei der Kontextualisierung Trance-ähnlicher Konzepte, einschließlich der Vorteile und der wesentlichen Grenzen des Neuroimaging.

Jan Mikulica
University of Konstanz, Germany

La neuroimagerie d'une suggestion élucide-t-elle la transe hypnotique?

Amir Raz

Résumé: Des études contemporaines dans le domaine de la neuroscience cognitive de l'attention et de la suggestion jettent une nouvelle lumière sur les mécanismes nerveux sous-jacents qui opérationalisent ces effets. Toutefois, si nous n'adhérons pas au principe de l'existence d'importantes limitations inhérentes à l'imagerie du cerveau humain vivant, les résultats d'études sur l'imagerie du cerveau risquent de susciter davantage de fascination que de fournir d'explications. Les chercheurs, praticiens, professionnels, et le public, doivent réaliser que l'influence exercée par les mots sur l'activité focale du cerveau est mesurable, mais que ces résultats sont souvent difficiles à interpréter. Bien que la recherche récente sur l'imagerie du cerveau incorpore un nombre grandissant de variables en matière de suggestion et d'hypnose, la corrélation entre les expériences hypnotiques globales et des substrats particuliers du cerveau demeure ténue. Cet article explique le rôle grandissant de la neuroscience cognitive, y compris les mérites relatifs et les limitations intrinsèques de la neuroimagerie, par voie de concepts mieux contextualisés apparentés à la transe.

Johanne Reynault
C. Tr. (STIBC)

Dilucidan las neuroimágenes de sugestión el trance hipnótico?

Amir Raz

Resumen: Estudios contemporáneos en la neurociencia cognitiva de la atención y la sugestión clarifican los mecanismos neuronales subyacentes que operacionalizan estos efectos. Sin adherirse a las salvedades inherentes a la imagenología del cerebro humano vivo, los resultados de estudios de imagenología cerebral podrían cautivar más que explicar. Los académicos, practicantes, profesionales, y consumidores deben darse cuenta que la influencia que las palabras ejercen sobre la actividad cerebral focal es medible, pero que estas mediciones frecuentemente son difíciles de interpretar. Mientras que estudios recientes de imagenología cerebral incorporan variaciones de sugerencias e hipnosis, la correlación entre la experiencia hipnótica global y sustratos cerebrales específicos sigue siendo tenue. Este artículo dilucida el creciente rol de la neurociencia cognitiva, incluyendo los méritos relativos y las limitaciones intrínsecas de la neuroimágen, en una mejor contextualización de conceptos relacionados con el trance.

Omar Sánchez-Armáss Cappello
Autonomous University of San Luis Potosi, Mexico