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The dreaming brain/mind, consciousness and psychosis ☆

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ABSTRACT

Several independent lines of research in neurobiology seem to support the phenomenologically-grounded view of the dreaming brain/mind as a useful model for psychosis. Hallucinatory phenomena and thought disorders found in psychosis share several peculiarities with dreaming, where internally generated, vivid sensorimotor imagery along with often heightened and incongruous emotion are paired with a decrease in ego functions which ultimately leads to a severe impairment in reality testing. Contemporary conceptualizations of severe mental disorders view psychosis as one psychopathological dimension that may be found across several diagnostic categories. Some experimental data have shown cognitive bizarreness to be equally elevated in dreams and in the waking cognition of acutely psychotic subjects and in patients treated with pro-dopaminergic drugs, independent of the underlying disorder. Further studies into the neurofunctional underpinnings of both conditions will help to clarify the use and validity of this model.

1. Introduction

Although almost all the funding pioneers of the modern scientific approach to mental disorders have in some way or another commented on the similarities between dreaming and insanity (Bleuler, 1966; Freud, 1958; Jung, 1936; Kraepelin, 1906; Minkowski, 1997), only few contemporary researchers have attempted to bind these complex phenomena (Gottesmann, 2006; Hobson, 2004). Indeed, most of the evidence supporting this observation belongs to a phenomenological perspective, which intrinsically lies on debatable premises due to its reliance on the verbalization of subjective experiences (Mishara, 2007; Parnas, Sass, & Zahavi, 2008). However, several recent neurobiological findings on both the architecture of dream sleep and severe mental disorders offer intriguing opportunities to bridge mental functioning to underlying brain activity across states.

Sigmund Freud was amongst the first to consider dreams at the centre of a complex theorization of mental functioning, and whether or not such theory may now be reconciled with neurobiology remains open to debate (Carhart-Harris, 2007; Hobson, 2004; Solms, 2004). Indeed, psychiatry's current loss of interest in dreaming may in part be attributed to a refusal of the central tenet of psychoanalysis, that has often been considered the extreme opposite of a rational scientific approach to the mind. Moreover, dreaming is usually considered a physiological phenomenon of little use in the clinical approach to mental disorders, although several psychologically-oriented investigators have shown statistically significant disorder-specific variations in the dreams of psychiatric patients (Cartwright, Agargun, Kirkby, & Friedman, 2006; Sauteraud & Menny, 1997; Schredl & Engelhardt, 2001; Zanasi, Calisti, Di Lorenzo, Valerio, & Siracusano, 2010). Dreaming is one of several

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subjective experiences which may yield significant insight into the functioning of the brain/mind, but two peculiar aspects make it particularly useful in terms of experimental evaluation. First of all, dreaming is generated by the brain in absence of interaction with the external world, possibly the purest form of mental production of a healthy brain (Revonsuo, 2006). Secondly, dreaming recurs with high frequency and little interindividual variability in most human subjects. Although an obvious inter- and intra-individual variability can be found in terms of dream content, the formal organization of this type of mentation appears to be fixed (Scarone et al., 2008; Stickgold, Rittenhouse, & Hobson, 1994). It has been suggested that themes, emotions and plots of dreams and their intrinsic bizarreness are as much generic to human consciousness as to individual consciousness (Hobson & Kahn, 2007). Two recent theories on dreaming both consider this phenomenon a biologically determined system that has served an evolutionary function for mankind (Hobson, 2009; Revonsuo, 2000). Although they have been reached from different perspectives, Antti Revonsuo's Threat Simulation Theory and Allan Hobson's Protoconsciousness Theory both imply that the phenomenology of dreams is generic and shared amongst individuals.

In this paper we will review evidence in support of the view that the dreaming brain/mind resembles psychosis independent of diagnostic categorizations, and may as such be considered a useful experimental model of this complex phenomenon. We believe a convergence of phenomenological and neurobiological observations to be necessary in order to clearly identify these two states of consciousness and their connections.

2. Phenomenology

The term psychosis has been variously defined in psychiatric literature, and both researchers and clinicians struggle to converge on a common definition of this phenomenon that may be considered satisfying. The Fourth edition of the Diagnostic and Statistical Manual of Mental Disorders opted for a restrictive definition of psychosis, to be preferably used as a term encompassing those serious mental disorders where the individual "loses touch with reality" (APA, 2000). Although the Manual itself stresses the need to consider such a definition as an operative simplification given the complexity and variety of clinical presentations, this view of psychosis seems to adequately follow in the European tradition of psychopathologists such as Eugène Minkowski (alienation), Kurt Schneider (passivity) and Karl Jaspers (loss of critical capacities and judgment over one's experience). Today, it is broadly accepted that psychosis may occur in the context of several clinical conditions, ranging from schizophrenic and affective disorders to neurological, metabolic and substance-related conditions. However, having the term psychosis often been conceptually bound to schizophrenia, it is not uncommon to find these two terms used as synonyms both in clinical practice and in research settings. Recent dimensional approaches seem to clarify the relationship, with psychosis considered the positive-symptom dimension of schizophrenia, with cognitive impairment and negative symptoms being the two other most common (van Os & Kapur, 2009). In our view, positive symptoms such as abnormal senso-perceptual experiences or thought processes ranging from ideas of reference to highly structured delusions, share substantial similarities with dream phenomenology.

Any form of conscious experience referred by a subject upon awakening, that can be assumed to have occurred during sleep, can be considered a dream. Such experience may be described along a continuum ranging from simple images, emotions or wake-like thoughts to full blown, complex, hallucinoid scenes within which the dreamer is immersed and within which often articulate storylines unravel, with intense interactions with animate and inanimate objects. The capability of the brain/mind to generate a full hallucinoid scenographic representation of reality (indeed, a form of virtual reality) is undermined by several elements of impossibility and incongruence of which the dreamer however is aware only upon awakening. Several experimental data point to bizarreness as a key feature of dream mentation, which may be viewed in its formal outline as a loosening of associations whereby incongruous elements are continuously juxtaposed in the dream sequence, be they emotional or related to characters, objects or actions. Such peculiarity has been related to an absence of language-dependent cognitive processes in dreaming such as self-reflective awareness, abstract thinking and metacognition (Hobson, 2009). In dreaming, the blockade of interactions with the external world is determined by modifications in underlying sleep physiology, giving rise to quantitatively and qualitatively varying percepts involving all sensory modalities. Psychotic symptoms in clear wakefulness may be viewed as a dynamic interplay between the external reality feedback and similar emotion and perception-related internal sources. The subject's inability to assess the internal origin of such sources could be attributed to a deficit of self-monitoring mechanisms that has been extensively related to schizophrenic psychoses (Stephan, Friston, & Frith, 2009; Wiffen & David, 2009).

3. Neurobiology

Although dreaming was originally associated with REM sleep, many convincing data have shown that some type of mental activity is possible during other stages of sleep. Human experience may be divided in three broad mental states: waking consciousness, dream consciousness and non-consciousness. In terms of brain neurophysiology, these three states are supposedly sustained by wakefulness, dream sleep and dreamless sleep (Tononi, 2000). Non-consciousness may also be found in pathological conditions such as coma and anaesthesia, although some form of consciousness may be present (Mashour, 2006). Indeed, within such theoretical framework, intermediate states of consciousness must be considered possible, as those found in neurological disorders affecting the brainstem, where a fluctuating consciousness determines oscillations in vigilance and orientation that contribute to emerging abnormal mental phenomena (D'Agostino and Limosani, 2009).

The REM stage of sleep has been defined more clearly in terms of neurochemical and neurofunctional activation that seem to correlate with the subjective experience of dreaming in which imagery is more vivid and storylines more articulate and incongruous. REM-like neurobiological modifications have been hypothesized to underlie similar subjective experiences during different EEG-defined stages of sleep, so we will refer to dream sleep, a neurobiologically defined state of the brain/mind within which dreams occur, ranging from full hallucinoid dreams (REM-like activation) to simple thought-like experiences. Although a direct correlation between dreaming and underlying neurofunctional modifications is still a major challenge for sleep/dream researchers, some REM sleep studies have shown a relative hyperactivation of cerebral regions related to emotional and affective life, like amygdala and anterior cingulated cortex, and a relative hypoactivation of the frontal cortex, mainly in its dorsolateral prefrontal regions (Braun et al., 1997; Maquet et al., 1996; Nofzinger, Mintun, Wiseman, Kupfer, & Moore, 1997). This functional condition of the brain is mediated by a complex and interactive neurochemical pathway that recognizes a strong increase of cholinergic activity in the Ascending Reticular Activating System (ARAS) and the silence of serotonergic and noradrenergic neurons (Morgane & Stern, 1972). This basic and well established assumption has been more recently completed by a series of reports claiming for a complementary role of dopaminergic mesolimbic activation (Solms, 1997) and/or of dopaminergic mesocortical activation with the simultaneous absence of serotonergic cortical inhibitory modulation (Gottesmann, 2002). The positive neurochemical feedback that has been found between the cholinergic and dopaminergic systems (Murray et al., 2004; Perl, Ilani, Strous, Lapidus, & Fuchs, 2003; Perry & Perry, 1995; Sarter & Bruno, 1999, 2000) warrants future research on the involvement of dopamine in sleep mentation. A raise in cortical dopamine activity has indeed been causally linked to the generation of nightmares, possibly implying an intensification of cholinergically-driven characteristics of REM sleep-related dream mentation (Thompson & Pierce, 1999).

These neurobiological findings seem to explain a copious portion of the subjective experience of dreaming, within which emotion is usually heightened and Ego functions in general (most prominently orientation in space and time, reality testing, self-monitoring mechanisms) tend to be suppressed. The DorsoLateral PreFrontal Cortex (DLPFC) has been extensively correlated with this type of function and its suppression in dream sleep probably accounts for orientational instability and inability to focus attention voluntarily and engage in goal-directed voluntary behaviour.

In NREM stages of sleep, bursts of "covert" REM sleep have been hypothesized to underlie dream mentation, as strongly suggested by "intermediate sleep" and Sleep Onset (SO) findings (Nielsen, 2000). In the former, EEG configurations containing elements of both REM and NREM have been correlated to hallucinatory subjective experiences. In SO, during which many electrophysiological signs of REM sleep – such as transient EMG suppressions and phasic muscle twitches – can be recorded, the most vivid NREM mentation reports have been collected (Cicogna, Cavallero, & Bosinelli, 1991).

Similar observations have experimentally been supported by neuroimaging data in psychotic subjects, with abnormal neuroanatomical findings in frontal lobes subsequently confirmed by fMRI studies showing hypoactivity of the DLPFC with reciprocal hyperactivation patterns in limbic structures (Glahn et al., 2005; Minzenberg, Laird, Thelen, Carter, & Glahn, 2009; Molina, Sanz, Sarramea, Benito, & Palomo, 2005; Weinberger & McClure, 2002). The most significant evidence in support of a neurobiological-dysfunction theory of psychosis is the effect of antipsychotic molecules on florid symptomatology, such as hallucinations and anguish related to delusional ideas and agitation or disorganized behaviour. Indeed, dopamine has long been thought to hold a central role in schizophrenic disorders, and one should expect to find most of these findings in other psychotic states (Howes & Kapur, 2009). Recently, prefrontal hypoactivity and striatal dopaminergic hyperactivity was found in combined PET/fMRI study in drug-naive subjects with a very high risk of developing psychosis (Fusar-Poli et al., 2010). However, several other neuromodulatory systems and most prominently acetylcholine have been theoretically involved in the emergence of psychotic symptoms (Raedler, Bymaster, Tandon, Copolov, & Dean, 2007; Sarter & Bruno, 1999).

4. Experimental evidence

Since Sigmund Freud's Interpretation of Dreams (Freud, 1965), clinical and theoretical interest in dreams has mainly focused on the content of the oneiric narrative often yielding contrasting data that are difficult to correlate with neurobiological findings. A modern approach to dream research is to focus on the formal aspects of the narrative, in order to find recurring cognitive patterns both within and inbetween subjects. Dream bizarreness is a cognitive construct which refers to the formal architecture of mental processes in dreams, and has been conceptualized as the distinguishing feature of dream consciousness, characterized by improbability, incongruity and vagueness in the domains of dream plot, characters, objects etc. and in the dreamer's thought processes and emotion (Hobson, Hoffmann, Helfand, & Kostner, 1987). Given the implicit relationship to schizophrenic patients' often incongruous and bizarre waking experience, dream bizarreness has often been evaluated in this population: Whereas some early studies found less bizarreness in comparison to the dreams of a normal control population (Carrington, 1972; Dement, 1955; Okuma, Sunami, Fukuma, Takeo, & Motoike, 1970), the recent literature seems to point to statistically equivalent (Lusignan et al., 2009) or even higher (Noreika, Valli, Markkula, Seppälä, & Revonsuo, 2010) bizarreness scores in the schizophrenic patients. Higher levels of bizarreness in the dreams of schizophrenic patients have also been found in comparison to the dreams of other psychopathological patient groups (Schredl & Engelhardt, 2001). Amongst these studies, waking thought reports were only collected in an unstructured manner (reclined relaxation in a dim lit room) in a sample of five patients, but the bizarreness scored was not reported (Noreika et al., 2010). Indeed, the objective measurement of subjective experiences is complex and limited by the well-known barrier of subjective–objective transfer (Dennett, 1991): If the dream experience is to be related to underlying brain phenomena, one must accept the

limitation of analyzing verbal reports that are invariably influenced by the subject's verbal fluency, general cognitive abilities, education, etc. rather than the dream experience itself. Similar limitations are intrinsic to research into waking cognition.

Waking fantasies elicited by the TAT (Thematic Apperception Test) projective were chosen by our group to experimentally compare states of consciousness. In keeping with the aforementioned observation of dreaming as the purest type of mental activity, fantasy may be considered the most similar type of mentation that occurs within the framework of wakefulness. Most significantly, fantasies have been found to result from a partial blockade of external stimuli, with attention focused on one's internal world (Starker, 1982).

Cognitive bizarreness was found to be similarly elevated in the verbal reports of waking fantasies of acutely psychotic schizophrenic subjects and in the dream reports of both psychotic and control subjects. These results suggest that, under experimental conditions, the waking cognition of schizophrenic subjects shares a common degree of formal cognitive bizarreness with the dream reports of schizophrenic and control subjects (Scarone et al., 2008). Similar results were found by our group when two judges blind to diagnosis scored waking fantasies and dream reports of 20 acutely psychotic schizophrenic, 20 acutely psychotic manic patients and 20 age- and education-matched control subjects. The same level of cognitive bizarreness was found in the fantasy and dream reports of the patient population, whereas it was almost completely absent in the fantasies of the control group (unpublished data). In this light, cognitive bizarreness appears to be a shared feature of dreaming and psychotic mentation, beyond diagnostic categorizations, supporting the view that a shared mechanism of brain/mind activation similar to that occurring during dream sleep underlies these clinical conditions.

Cognitive bizarreness was also found to be elevated in the dream and waking cognition of subjects treated with prodopaminergic drugs for Parkinson's Disorder (PD), suggesting a possible involvement of the cholinergic/dopaminergic balance that is thought to play a central role in PD and schizophrenia as well as in dream sleep (D'Agostino et al., 2010).

5. Conclusion

In spite of several promising advances in neuroscience and psychiatric disorders, clinicians and researchers alike are still at some distance from addressing the core of the problem, the loss of touch with reality. The possibility of using a universal and shared experience to which any observer may have a direct access makes the dreaming model of psychosis particularly useful. Furthermore, dreaming may be studied neurobiologically in healthy subjects that have never taken psychotropic medications or other psychoactive substances. Indeed, research into psychosis is often complicated by the presence of significant drug regimens of which some major effects cannot be excluded.

Schizophrenia – a multifaceted disorder – is still the clinical condition within which psychosis may be diagnosed most frequently, and peer-reviewed research into neurobiological and experiential correlates of psychosis is usually derived from schizophrenic patients. For this reason, it is frequent to find an erroneous equation schizophrenia = psychosis in clinical practice and research settings, whereas several aspects of psychosis are known to occur in different disorders and schizophrenia with no relevant psychotic symptoms can occur. It is well known that a great variety of predisposing conditions may precipitate psychosis, namely schizophrenia, manic-depressive illness, unipolar depression, mental retardation, drug intoxication and withdrawal, several metabolic or neurological conditions affecting the anatomy and physiology of the brain. Furthermore, psychosis can occur in response to sensory deprivation such as seclusion and highly stressful events, and underlying neurobiological mechanisms have been hypothesized to involve stress-response cascades resulting in hyperdopaminergic activity in the cortex (Corcoran, Gallitano, Leitman, & Malaspina, 2001). Amongst these conditions, the psychotic experience can be variously expressed from an isolated reference ideation, abnormal self experiences or neurological hallucinoses to full blown, agitated florid substance-induced psychoses. Likewise, dreaming is not a binary experience, either recurring or not, but it may be conceptualized along a continuum from brief sleep-related hallucinatory experiences to intensely vivid or even lucid REM-rebound dreams.

Although it is not clear how sleep resembles psychosis, a common underlying mechanism may be found in an evolutionary perspective, with similar processes occurring at the genetic, biochemical and ultimately neurofunctional level in both the emergence of dream sleep in all human subjects and of psychosis in a relatively small percentage of them. In these terms, dreaming has been hypothesized to be a subjective experience lacking secondary consciousness, several aspects of which can be similarly found to diminish in most psychoses (Hobson, 2009).

Several experimental data seem to indicate that coherent integration of activity between functionally specialized regions may bind information into a subjective experience (Edelman & Tononi, 2001; Llinás & Paré, 1991; Massimini, Tononi, & Huber, 2009). Out of several available techniques to study brain function, electroencephalographic recordings appear to offer the highest temporal resolution, which is necessary to study the neural underpinnings of complex subjective phenomena (Babiloni, Babiloni, Carducci, Cincotti, & Rossini, 2003). Quantitative EEG recordings in psychotic subjects have thus far yielded mixed results. β and γ oscillations and their synchronization have been found to be reduced during cognitive tasks and at rest in schizophrenic subjects, suggesting an intrinsic deficit in the temporal coordination of distributed neural activity (for a review, see Uhlhaas & Singer, 2010). Whether or not modifications in brain function found in schizophrenia are specific to the disorder or to a symptomatology that can be found across other conditions, and whether psychosis may emerge as a result of such modifications in a similar way to physiological modifications underlying dream activity remains to be understood.

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