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THEORETICAL REVIEW

Neural correlates of insight in dreaming and psychosis

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SUMMARY

The idea that dreaming can serve as a model for psychosis has a long and honourable tradition, however it is notoriously speculative. Here we demonstrate that recent research on the phenomenon of lucid dreaming sheds new light on the debate. Lucid dreaming is a rare state of sleep in which the dreamer gains insight into his state of mind during dreaming. Recent electroencephalogram (EEG) and functional magnetic resonance imaging (fMRI) data for the first time allow very specific hypotheses about the dream–psychosis relationship: if dreaming is a reasonable model for psychosis, then insight into the dreaming state and insight into the psychotic state should share similar neural correlates. This indeed seems to be the case: cortical areas activated during lucid dreaming show striking overlap with brain regions that are impaired in psychotic patients who lack insight into their pathological state. This parallel allows for new therapeutic approaches and ways to test antipsychotic medication.

Introduction

Rapid eye movement (REM) sleep is the sleep stage associated with the most vivid and intense dreams. These internally generated perceptions and emotions typically show many cognitive peculiarities, with a bizarre plot, delusional thought, and a complete lack of insight into the true state of the subject. In this regard, dreaming resembles the psychosis of mental illness such as schizophrenia, characterized by hallucinations, loosening of associations, incongruity of personal experience, and a loss of self-reflective capacity [1,2]: both the psychotic patient and the dreamer fail to discern self-generated from non-self-generated percepts, and uncritically accept bizarre experiences as real [3].

The idea that dreaming can indeed serve as a model for psychosis has a long and honourable tradition: Kant [4] likened the madman to a waking dreamer, Schopenhauer [5] considered the dream a brief madness and madness a long dream, and also modern psychiatrists such as Bleuler, Kraepelin, Freud or Jung stressed the similarities between dreaming and psychosis [6]. While these historical proposals to consider dreaming as a model for psychosis are notoriously speculative, they are supported by recent studies of dream phenomenology: dream reports of healthy subjects include more quasipsychotic experiences than their reports of experiences during wakefulness [7], and striking similarities in cognitive bizarreness measures were found between the waking thought of psychotic patients and dream reports of either patients or healthy controls [6,8–12]. In other words, whereas healthy subjects experience strong fluctuations of bizarre and hallucinated cognitive elements across the sleep–wake cycle, psychotic patients continuously experience such dream-like mentations during both waking and dreaming [13]. Interestingly, also during wakefulness, psychotic patients consider their dream reports as being less bizarre than healthy controls do, despite a similar density of bizarre elements as scored by external judges [14]. In addition, similarities between REM sleep and schizophrenia can also be observed at the neurobiological level [15], in particular noradrenergic demodulation was proposed to contribute to the cognitive disturbances that occur during dreaming and psychosis [16].

Insight in dreaming and psychosis

One of the most interesting aspects of the dreaming–psychosis model is the issue of insight: between 50 and 80% of the patients diagnosed with schizophrenia have poor insight into the presence

Abbreviations: EEG, electroencephalogram; fMRI, functional magnetic resonance imaging; MRI, magnetic resonance imaging; NREM sleep, non-REM sleep; REM sleep, rapid eye movement sleep; VBM, voxel-based morphometry.

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of their disorder [17], probably due to ineffective self-reflection processes [18]. Since such deficits are thought to lead to more relapses and rehospitalisations and poorer therapy success in general [19], the concept of insight is becoming an increasingly important area of investigation in schizophrenia research [20].

On the dreaming side of the model, lack of insight into the current state can be seen as a hallmark of dream cognition, characterizing almost any dream experience. From a theoretical point of view, this metacognitive deficit was proposed to be the most interesting feature of the dream state [21]. However in contrast to normal dreaming, a special kind of sleep mentation is characterized by a reinstantiation of reflective capacity: during lucid dreaming, the sleeping subject becomes fully aware of his or her true state [22]. A lucid dreamer recognizes dream hallucinations as such. Despite this wake-like reflection, lucid REM sleep comprises all defining markers of REM sleep proper [22] and all basal dream features such as visuomotor hallucinations [23] – in fact, prototypical aspects of dream phenomenology such as bizarreness might even be more pronounced in lucid dreams [24]. This suggests that lucidity may be a good model for insight in the dreaming–-psychosis model. Interestingly, historical approaches to psychosis used the term 'lucidity' to denote the awareness of the patient into his illness [25]. While the specific composition of the multiple facets of insight in psychosis is still under discussion [26–28], two crucial dimensions are classically considered to be the recognition that one has a mental illness and the ability to recognize unusual mental events (delusions and hallucinations) as pathological [29]. Hence, in the dreaming–psychosis model, lucidity during dreaming represents what patients during psychosis lack: full insight into the delusional nature of the current state of consciousness during that state.

This parallel between insight deficits in dreaming and psychosis allows for a new empirical test of the dreaming–psychosis model: If the model holds, insight into the current state of mind should share similar neural correlates during both dreaming and psychosis. Lucid dreaming can be trained [30,31], which makes this phenomenon a promising research topic despite the rarity of its occurrence in untrained subjects [32,33]. Two recent neurobiological studies on lucid dreaming show that significant results can be obtained even in limited subject samples [34,35]. These results can be compared with neurobiological studies of psychotic patients with insight deficits to critically evaluate the dreaming–psychosis model on a neural level. Thus, the specific hypotheses derived from the dreaming–psychosis model can be stated as follows: 1) neural correlates of dream insight (i.e., lucid dreaming) largely overlap with neural correlates of insight into the psychotic state. 2) means to achieve lucidity during normal dreaming will increase insight into the pathological state in psychotic patients. While the latter hypothesis has to be tested empirically with new studies, the former can be evaluated by reviewing the neuroscientific literature on dreaming and psychosis.

The dreaming brain

Dream-like mental activity can be observed during all sleep stages, however REM sleep dreams are particularly vivid and intense. The specific phenomenal characteristics of dreaming have frequently been associated with neural activation patterns observed during REM sleep. For example, during normal REM sleep, higher visual and motor areas show strong metabolic activity [36,37], which is in line with visuomotor hallucinations as the hallmark of typical dreaming [38]. Also the amygdala, medial prefrontal cortex and anterior cingulate cortex show increased activity during REM sleep [36,37]. All these brain areas have been implicated in emotional processing, nicely mirroring the intense emotions experienced in many dreams [38]. In contrast, the dorsolateral prefrontal cortex, parietal areas including the supramarginal cortex and precuneus, and the cingulate cortex show low metabolic rates during REM sleep [36,37]. In particular prefrontal deactivations have been postulated to underlie cognitive deficiencies typical of ordinary dreaming such as impaired critical thinking and restricted volitional capacities [38,39]. Growing evidence suggests that many behaviors share similar neural substrates during wakefulness and dreaming [40]. For example, dreamed hand movements activate the contralateral motor cortex consistent to their respective neural activations related to actually executed hand movements during wakefulness [33]. In recent years, network analyses of neuroimaging data have prompted new insights into the principles of brain organization during wakefulness and sleep. A recent meta-analysis has pointed out a striking overlap between brain regions that show increased metabolism during REM sleep and regions of the default mode network [41].

The lucid brain

While lucid dreaming is characterized by all coarse electroencephalogram (EEG) features of REM sleep according to classical sleep stage scoring [42], brain activity during lucid REM sleep shows distinctive changes compared to non-lucid REM sleep. Fig. 1 shows the increased EEG activation that was observed over the right dorsolateral prefrontal cortex during lucid dreaming [34]. In this study, three subjects out of 20 undergraduate students participating in three months of lucidity training were able to become lucid in the laboratory setting. Results showed lucid dreaming to have higher-than-REM activity in the gamma band, the between-states-difference peaking around 40 Hz. Overall EEG coherence levels during lucid dreaming were significantly higher than in non-lucid REM sleep. Both power in the 40 Hz band and coherence levels were strongest over the dorsolateral prefrontal region.

Fig. 2 illustrates activation increases during lucid as compared to non-lucid REM sleep in a combined functional magnetic resonance imaging (fMRI)/EEG approach [35]. In this study, four experienced lucid dreamers slept several nights in a magnetic resonance imaging (MRI) scanner under concurrent polysomnography. One subject had two episodes of verified lucid REM sleep of sufficient length to be analyzed by fMRI. Insight into the dreaming state was associated with activation in a network of purely neo-cortical regions including the dorsolateral and frontopolar prefrontal cortex, thus confirming the Voss et al. data. Strong activation increases during lucid dreaming were also observed in parietal regions including the precuneus, inferior parietal lobules and supramarginal gyrus and in occipito-temporal regions including the inferior/middle temporal gyri and lingual gyri. Prefrontal and parietal regions are involved in most higher cognitive processes like intelligence or working memory [43], in particular the dorsolateral prefrontal cortex has been associated with metacognitive evaluation [44,45]. The precuneus has been proposed to be the pivotal region involved in self-referential processing [46]. The frontoparietal activation pattern observed during lucid REM sleep therefore nicely mirrors the reinstantiation of reflective capabilities experienced during lucid dreaming. In contrast to the default mode network-like activation patterns of normal REM sleep [41], brain regions activated during lucid dreaming comprise substantial parts of the frontoparietal control network [35]. This network has been postulated to integrate information coming from both the default mode and attention networks by switching between competing internally and externally directed processes [47]. Due to this role as a kind of meta-network, the frontoparietal control network might