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REVIEWS

Review

Disruption of Conscious Access in Schizophrenia

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Schizophrenia is a severe and complex psychiatric disorder resulting in delusions, hallucinations, and cognitive impairments. Across a variety of paradigms, an elevated threshold for conscious perception has been repeatedly observed in persons with schizophrenia. Remarkably, even subtle measures of subliminal processing appear to be preserved. We argue here that the dissociation between impaired conscious access and intact unconscious processing may be due to a specific disruption of top-down attentional amplification. This proposal is compatible with the neurophysiological disturbances observed in schizophrenia, including dysconnectivity, abnormal neural oscillations, and glutamatergic and cholinergic dysregulation. Therefore, placing impaired conscious access as a central feature of schizophrenia can help researchers develop a coherent and parsimonious pathophysiological framework of the disease.

A Neuroscientific Approach to Consciousness in Schizophrenia

Schizophrenia (see Glossary) is a severe disease that affects approximately 0.6–1% of the general population around the world [1]. Since the first descriptions of schizophrenia [2,3] it has been observed that patients are unaware of their symptoms, disconnected from reality, and exhibit negative symptoms that affect both high-level and basic cognitive functions. However, only more recently has it become clear that patients with schizophrenia exhibit specific deficits in conscious processing that could underpin most of these symptoms. Although consciousness has long been an important research topic in psychology and philosophy, its definition has been operationalized with the rise of cognitive neuroscience [4]: information is considered conscious if subjects are able to report it. By experimentally manipulating whether information is presented consciously or unconsciously to participants, neuroscientists have been able to compare how the two different information types are processed and to identify the neurophysiological signatures of consciousness [5,6].

Capitalizing on this growing science of consciousness, here we review recent results showing that persons with schizophrenia exhibit a dissociated profile of impaired conscious access and preserved unconscious processing. We discuss the plausible mechanisms of such a dissociation in light of the **global neuronal workspace** (GNW) theory of consciousness and disentangle the role of bottom-up and top-down deficits in this specific disruption of conscious access. We then confront those experimental results with recently proposed Bayesian models of schizophrenia. Finally, in line with the GNW model and the pivotal role of glutamatergic and cholinergic transmissions in conscious access, we examine the neurophysiological and molecular mechanisms that may underlie the dissociation between impaired conscious access and preserved unconscious processing in schizophrenia.

Trends

Patients with schizophrenia exhibit impairments of conscious processing and an elevated threshold for conscious perception, while subliminal processing is preserved.

The sensory impairments in schizophrenia could be explained by a disorder of conscious top-down attentional amplification rather than by bottom-up processing deficits.

Bayesian models account for the emergence of delusions through inappropriate updating of conscious representations according to sensory evidence.

Brain-imaging and neurophysiological studies of schizophrenia reveal anomalies in long-distance connectivity and synchrony between distant brain areas that may have a pivotal role in the disruption of conscious access.

NMDA receptors may have an important role in the pathophysiology of schizophrenia: there is growing evidence that NMDA receptors are dysregulated in this affection, that they have a prominent role in long-distance top-down connectivity, and that their disruption may induce psychosis and disorders of consciousness in subjects without schizophrenia.

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Dissociations between Conscious Access and Unconscious Processing in Schizophrenia

Explicit versus Implicit Behavior

Many high-level cognitive functions, such as memory, attention, processing speed and executive functions, are broadly impaired in schizophrenia. It was proposed that, in some domains, schizophrenia specifically affects explicit cognitive processing, while implicit abilities remain preserved [7–9]. Indeed, persons with schizophrenia were found to exhibit a selective deficit in explicit recollection, but no impairment in implicit memory as measured by familiarity [7]. Implicit grammar learning was also preserved [8]. Patients also showed preserved implicit emotion processing while they were impaired in explicit emotion classification [10,11].

Conscious versus Subliminal Processing

The dissociation between explicit and implicit processing has been further explored by comparing conscious versus **subliminal** processing. Studies of visual masking revealed an elevated threshold for conscious perception in schizophrenia [12–18]. For instance, when a digit was presented for a fixed duration and then, after a variable delay, followed by a mask made of several letters, persons with schizophrenia needed a longer delay than controls to consciously perceive the digit (Figure 1A,B). Similarly, patients are less likely to report that they perceive an unexpected event during **inattentional blindness** [19] and showed an exaggerated attentional blink effect compared to controls, associated with a decreased P300 [20]. Patients' nonaffected first-degree relatives may also exhibit an elevated masking threshold, suggesting that this finding is independent of medication and is an endophenotype of schizophrenia [21].

Remarkably, however, patients appear to process subliminal stimuli normally, resulting in a dissociation between impaired conscious processing and preserved subliminal processing. For instance, in number processing, conscious visual masking is impaired in schizophrenia while subliminal **priming** is preserved [14] (Figure 1C). Controls and patients were asked to compare a target number to five. This number was preceded by a fast presentation of another number that served as a prime and could be rendered invisible by masking. In the control group, performance in comparing the target number to five was affected by the congruency between the prime and the target under conscious (i.e., unmasked) and subliminal (masked) conditions: subjects were faster to answer when the prime and the target were congruent (both more or both less than five) than when they were incongruent (one more than and the other less than). However, in the patient group, the priming effect was observed only with subliminal primes but not with visible primes (Figure 1C).

Normal subliminal processing in patients with schizophrenia has also been observed in studies involving inhibitory processing [22] and emotional face or gaze direction processing under **continuous flash suppression** [23,24]. Some studies even suggest that masked emotional priming [25] and unconscious semantic priming [26] are enhanced in patients compared with healthy controls. Similarly, in a **change blindness** paradigm, patients moved their eyes toward the changes faster than did controls, suggesting normal or even enhanced unconscious processing, while their capacity to explicitly detect and report the changes was reduced [27]. Indeed, in the same studies, as soon as the threshold for conscious perception was crossed, conscious processing was impaired in schizophrenia, including inhibitory processing [22], number comparison [15], conscious priming [15], and conflict detection [14,28].

Impaired Metacognition and Conscious Error Detection

Metacognition, the ability to represent and monitor one's own mental state, is also subject to this dissociation between altered conscious processing and preserved unconscious processing. For instance, a recent study assessed conscious and unconscious error monitoring, using subjective reports and an electrophysiological measure of error detection, in controls and

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