Chapter 38
Can AI Improve Consciousness Disorders Diagnosis?

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Abstract Consciousness is potentially the final frontier of knowledge about the human brain. For over a century, scientists from different disciplines—neuroscientists, physicists and, recently, experts in artificial intelligence—have been trying to unlock the brain's innermost secrets. Curiously, psychopathology, which could have contributed greatly to this objective, has remained on the sidelines of this debate. Yet, many psychopathological disorders are naturally related to consciousness: from quantitative to qualitative disorders, from dereistic experiences to dissociative disorders and more. Despite the formidable development of innovative methods for understanding the brain, the more we know about its functions, the more complex the explanations appear. Its organization seems to be vastly more intricate than we thought until a few decades ago. The aim of this work is to show the complex, multi-layered processes underlying disorders of consciousness, the challenges posed by their identification and diagnosis, and how recent unimaginable innovations in AI technologies used in prediction and simulation tasks can provide novel insights into crucial areas of inquiry such as the birth and emergence of the Self and the disturbances of its fundamental structures.

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38.1 Introduction

For over a century, psychopathology has remained largely uninvolved in the debate on consciousness, despite its obvious implications for relational life. One considers the consciousness that enables internal debates about ethical, aesthetic, and other issues; sleep–wake rhythm disorders and hypervigilance; states of attentional and perceptual lucidity; emotional-affective integration; psychic symptoms related to physical pain; the maintenance of psychic coherence and unity; and so on. Regardless of how one views consciousness, psychopathology appears to be the primary means of reducing the distance between subjective and objective, psychological and neurobiological spheres. To date, however, despite the growth of knowledge, the difficulties in understanding the functioning of consciousness remain unresolved [1]. There is concern that without a perspective integrating the considerable amount of data at our disposal, these difficulties will only deepen.

In general, most scientists agree that consciousness originates from a proto-experience integrating cortical and subcortical activity [2–4]. We could not conceive, except under these conditions, those states of attentional and perceptual awareness that, at varying degrees of intensity, enable the performance of crucial functions in relational life. Consciousness, as a subjective experience of a system in action—unlike vigilance, which can be quantitatively measured—poses serious challenges for experimental investigation. About a century ago, Bleuler [5] attempted to distinguish between alterations in states of consciousness caused by organic lesions and those attributable to psychopathological conditions. Around the mid-twentieth century, Ey [6], through a refined synthesis of the concepts of “organization,” “intentionality,” and “perceptual field,” defined the field of consciousness as a space within which experience is realized in its transience and synchronicity. This insight now helps us better understand the genealogy, background, and multilevel overarching organization of consciousness, and, most importantly, how disorders of consciousness manifest in neurocognitive and personological dimensions [7, 8].

Certainly, in the presence of qualitative alterations, it is challenging to speak of disorders of consciousness, as consciousness always transcends its field of action. The classic distinction between quantitative-categorical levels (attention, vigilance, sleep, coma) and qualitative-dimensional levels (subjective experiences such as sensations, thoughts, emotions) intersects with the articulation of different levels of consciousness: synchronic (the field of consciousness) and diachronic (the ego or personality). The way consciousness integrates and transforms reality data affects every aspect of our relational life [9]. For instance, consciousness can be significantly modified by a deliberate mental act, as in meditation or contemplation. Moreover, it is the clear awareness of our presence—that is, of being ourselves who think, know, will, and act—that represents the constraint anchoring us to reality, in contrast to states characterized by a loss of familiarity with ourselves and the world around us, which blurs the boundaries of the Self.

38.2 The Discontinuity of Consciousness

Historically, a distinction has been made between quantitative and qualitative disorders of consciousness. The former refer to conditions affecting attention, vigilance, and other objectifiable spheres (dullness, numbness, coma, and some organically based clinical syndromes). The latter pertain to the contents of consciousness, the experience of the self, and the surrounding world (depersonalization, derealization, dissociative phenomena, somatic conversion disorders, oneiric and oneiroid states, confusional and crepuscular states) [10, 11]. Although a clear and accurate demarcation between these two clinical spheres is difficult, an artificial classification is necessary for their relevance to a scientific understanding of consciousness.

Thus, at least four levels of quantitative disorders of consciousness can be identified [11, 12]:

Level 1: This includes symptoms such as torpor, diminished states of consciousness, and hypnoid changes. The patient still distinguishes themselves from the outside world, fantasy from reality, recognizes people, and falls asleep normally. This is the first stage towards a precoma state. The etiopathogenesis can be traced to organic causes: brain trauma, severe metabolic alterations, tumors, or immoderate use of alcohol and drugs.

Level 2: This encompasses symptoms such as oneiric and oneiroid changes with quantitative and qualitative associative abnormalities, distortion of reality checks, and the presence of delusional and hallucinatory cues. The distinction between reality and fantasy is partially preserved. These conditions occur in organically based confusional syndromes (delirium) and in the acute phases of schizophrenia and mania.

Level 3: This includes symptoms such as a sudden onset and time-limited narrowing of the field of consciousness, which generally resolves with restitutio ad integrum. The patient appears self-absorbed and unable to integrate temporal and spatial experiences. There is no incoherence or dullness, but dysphoria, mystical-ecstatic states, and poor memory of what happened are present. Such disturbances are psychogenic in origin and occur in syndromes such as somatic conversion, post-traumatic stress, prolonged imprisonment (Ganser syndrome), and can also be brought about by epileptic attacks, head trauma, and drug use.

Level 4: This comprises symptoms such as a state of confusion with lack of insight, linguistic incoherence, loss of temporal-spatial orientation, disorganization of thought and language, disturbances of perception (illusions, hallucinations), and alterations in sleep–wake rhythm. They occur in delirium, acute and chronic organic confusion syndromes, trauma, dysmetabolic disorders, tumors, and toxic states.

Qualitative disorders of consciousness include derealization and depersonalization phenomena, dissociative identity disorders, psychogenic amnesia, somatoform and somatic conversion disorders, and more [13]. These signs and symptoms can be ascribed mainly to medical causes (mostly secondary to cerebral alterations) or to psychic causes, insofar as they are the expression of a defense intervening in extreme circumstances (traumas) and unconscious conflicts that act as a barrier to anguish that cannot otherwise be organized.

38.3 Neural Dissonances in the Centrencephalic Space

The harmonic integration of consciousness is strongly altered by the intake of psychoactive substances: cannabinoids, psilocybin, mescaline, lysergic acid, and more recent ones. The pharmacodynamic effects of these substances include phenomena such as “thought diffusion” (where the patient has the impression that thoughts are spreading in the environment), the “fearful change,” and the feeling of being at the mercy of dark forces that recurs in the onset of schizophrenia, hypnotic states, and more. Whether the disorder is quantitative or qualitative, the psychopathological study must always be framed in the context of the relationship between cortical and subcortical structures. It is now well-established that the recovery of consciousness is related to an activation of deep brain structures, rather than the cerebral cortex. In fact, the state of consciousness is preceded by the intensification of metabolic activities in the centrencephalic archipelago, consisting of the thalamus, the limbic system, and the lower frontoparietal cortical areas [14]. Progressive levels of consciousness, up to the apex of self- and world-awareness, measured by the response to vocal commands, are related to these neural territories. It is of great interest that the activity of deep brain structures is also targeted by anesthesia, suggesting the presence of a common autonomous arousal mechanism. In general, the study of the effects of anesthetic drugs and their ability to modulate consciousness opens new scenarios for research. The suspension of relational life and the slipping into a state of oblivion and, conversely, the recovery of the sense of awareness when the pharmacological effect wears off, represent phenomena of extraordinary importance for understanding consciousness.

The comparison between the physiopathological states related to the lack of consciousness (deep sleep, coma/vegetative state, general anesthesia, loss of consciousness during an epileptic crisis) has highlighted how these conditions, although ascribable to different etiopathogeneses, share a series of objective elements: normal electroencephalographic activity, a significant decrease in frontoparietal metabolism, functional cortico-cortical and thalamo-cortical inhibition, and a state of “non-responsiveness” [15, 16]. These effects shed more light on some aspects of the structure underlying consciousness and its functions. For example, in the absence of apparent disorders of consciousness or altered “attunement,” patients can rest adequately, show alertness, and converse appropriately. Often, however, they do not know where they are or where they come from, get lost on the way, do not orient themselves in time, forget their age, and are frequently unable to recover lost information.

Although scientific research has moved in other directions, vigilance and awareness remain key concepts in the clinical definition of altered consciousness. One need only consider the involuntary closing of the patient’s eyes, which is regarded as a simple closing of their consciousness to the world. In this sense, if in comatose patients consciousness has vanished (and, in the most serious cases, vital functions such as breathing must be assisted mechanically), in the vegetative state, often corresponding with sleep–wake cycles, the patient alternates between closing and opening their eyes, and there may be afinalistic motor activity and facial expressions. Of course, there are many factors to consider: for example, before slipping into a vegetative state, patients often remain in a coma state for weeks, after which the possibility of total irreversibility increases.

Alongside vegetative states, there are minimally conscious states. Here, the inclusion criteria appear different from those of the vegetative state and, consequently, the diagnostic-nosographic classification of this syndrome becomes more complex, where awareness is almost abolished or fragmented. Although transiently, patients seem to interact with the world spontaneously or under stimulation for tasks of minimal complexity and not prolonged in time [17, 18]. These two clinical pictures seem to have some traits in common and, for this reason, they have been framed in a clinical spectrum called "low level neurological state," which replaces obsolete concepts such as alert coma, apallic syndrome, and so on. For patients with disorders of consciousness, conceptual ambiguities in the definition of consciousness affect diagnostic conclusions about the patient's state. Current imaging technologies make it possible to identify correlates of consciousness and therefore enable more accurate diagnostics. Classification technologies coupled with parallel developments in deep learning add a further dimension to the interpretation of such phenomena, revealing structured information content and distributed causal influences [19].

38.4 Future Applications

Due to the severe difficulties in diagnosis, an important emphasis in the classification process is not only on the implementation of neurological knowledge (i.e., discerning typical signs and symptoms of disorders of consciousness) but also on how artificial neural networks can record previously undetected features of consciousness that influence such disorders, guiding treatment and prognosis [19, 20]. Among the crucial tools is certainly AI-based predictive learning: existing training on datasets, now based on unsupervised, predictive learning, is significantly expanding the possibilities of integrating greater amounts of multimodal data. Through recent advances in AI that emphasize neural network-based paradigms [21], this learning approach does not rely on isolating discrete elements within data samples but extracts correlations that allow reconstruction of the data from these correlations, further increasing the spectrum of detectable phenomena and usable information—such as through image recognition and signal processing [22, 23]. This expands the range of possible tools for clinicians through a blended method that is now being explored and has already found some promising applications in the assisted detection of psychopathological disorders [24–29] and in guiding or monitoring the psychotherapeutic process itself [30, 31].

In sum, artificial neural networks have the potential to offer a qualitatively new dimension in the diagnosis of disorders of consciousness and could supplement currently available methods. These networks could provide tools that would be able, through the non-linear processing of massive amounts of multidimensional data, to give access to indicators of conscious activity and its disturbances that are as of now inaccessible.

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