

Impaired self-awareness in human addiction: deficient attribution of personal relevance

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Compromised self-awareness of illness-related deficits and behaviors in psychopathology (e.g., schizophrenia) has been associated with deficient functioning of cortical midline regions including the ventromedial prefrontal cortex (vmPFC), implicated in personal relevance. Here, we review and critically analyze recent evidence to suggest that vmPFC abnormalities could similarly underlie deficient tagging of personal relevance in drug addiction, evidenced by a constellation of behaviors encompassing drug-biased attention, negative outcome insensitivity, self-report/behavior dissociation, and social inappropriateness. This novel framework might clarify, for example, why drug-addicted individuals often ruin long-standing relationships or forego important job opportunities while continuing to engage in uncontrolled drug-taking. Therapeutic interventions targeting personal relevance and associated vmPFC functioning could enhance self-awareness and facilitate more adaptive behavior in this chronically relapsing psychopathology.

Self-awareness in drug addiction

Drug addiction is characterized by compromised decision-making and behavioral monitoring, and inflexibility in modifying previously rewarded behaviors that no longer produce favorable outcomes [1]. We previously posited that these compromises in addiction might embody a core deficit in insight and self-awareness, attributable to abnormalities in select brain regions including the anterior cingulate cortex (ACC) [2]. The current opinion article supports, yet refines this hypothesis. In particular, we posit that, as with other neuropsychiatric disorders of impaired self-awareness (e.g., schizophrenia, Alzheimer's disease, focal brain lesions), impairments of self-awareness in addiction may reflect an underlying abnormality in the attribution of personal relevance to salient stimuli (for a more extended definition of self-awareness, see [Box 1](#)). We further posit that this deficit could be undergirded by aberrant functioning of the prefrontal cortical (PFC) midline regions

traditionally implicated in self-related processing. Such dysfunction may culminate in elevated personal relevance of drug contexts, but not of other important contexts (e.g., ongoing behavior, social cognition). We place special emphasis on the ACC, especially of its more rostral (also referred to as perigenual) aspects (rACC) [Brodmann areas (BAs) 24 and 32]), extending ventrally and anteriorly to include portions of the vmPFC (BAs 10, 11, and 25) ([Figure 1](#)). (For a discussion of a broader self-awareness network, e.g., inclusive of more lateral regions such as the insula, see [Box 2](#).) Because impaired self-awareness is typically associated with increased severity and poorer prognosis across multiple diseases [3], this topic has both theoretical and clinical importance.

The rACC/vmPFC: emotionally tagging stimuli for personal relevance

The rACC (and adjacent anterior medial PFC) forms part of the network that supports self-related processing, with the specific hypothesized function of tagging stimuli as being personally relevant [4,5]. This region is involved in generating the affective response that may occur shortly after error commission [6] and in resolving emotional conflict [7]. Relatedly, the rACC activates during the experience of negative self-conscious emotions, including embarrassment [8], and after receiving emotion-laden feedback [9]. The rACC is also implicated in one's sense of agency, activating when individuals gamble for themselves versus when a computer gambles for them [10]. The rACC activates even when, through mental imagery, neutral stimuli become associated with the self [11].

This perspective extends ventrally to the vmPFC, which participates in the highly related function of appraising or representing the personal value/significance of self-related information [12]. For example, the vmPFC activated when participants imagined objects belonging to them versus when they imagined objects belonging to someone else [13,14]. This region also showed a descending level of engagement when participants were asked to think about a personally relevant target (one's mother), an intermediately relevant target (George Bush), and a non-personally relevant target (Cinderella), respectively [15]. This hypothesized function of the vmPFC squares well with the more generally recognized roles of this region in computing or representing the subjective value of various types of stimuli [16–18].

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Box 1. New emphasis for the definition of self-awareness in addiction

Deficits in self-awareness can range from complete denial of the entire illness to more specific metacognitive awareness deficits of individual disease-specific symptoms, impairments, or performance, and may vary between psychopathologies [3]. For example, self-awareness impairments are more severe in schizophrenia than in mood disorders [54]. In drug addiction, consistent with its overall neuropsychological profile [55], self-awareness impairments are anticipated to be relatively mild.

Here, we operationalize self-awareness impairment as the failure to ascribe personal relevance or significance to internal or external stimuli or events that have implications for the self – be they environmental cues/feedback, interoceptive sensations, or ongoing behavior. This operationalization is distinct from other related concepts that may be conflated with self-awareness, such as self-attribution processes, self-monitoring, and self-consciousness, personal agency, consciousness/alertness, interoception, or alexithymia. These related concepts may be distinguished from our current self-awareness formulation according to the following. (i) Motivation: self-attribution is generally invoked to explain avenues that individuals use to preserve and enhance self-esteem (e.g., ascribing positive outcomes to skill and negative outcomes to bad luck) [56]. Likewise, self-monitoring [57] and self-consciousness [58] are dispositional tendencies in which the motivation is to present the

self favorably to others. Here, we view the actual expression of self-awareness deficits as being motivationally agnostic or ambivalent. Deficient oversight of one's behavior (e.g., error awareness) or insensitivity to negative outcomes (e.g., money loss) may occur despite sufficient task motivation and compliance with task demands. (ii) Cognition: personal agency reflects the dispositional tendency to understand one's behavior in terms of its consequences and implications (i.e., 'why' a behavior is executed) or, alternatively, in terms of its details or mechanics (i.e., 'how' a behavior is executed) [59]. With self-awareness, the focus is on whether a particular behavior, when executed, is meaningful to the self. (iii) Attention: consciousness generally refers to the degree of alertness to one's environment (e.g., ranging from coma, sleep, daydreaming, to full task engagement). In our formulation, self-awareness deficits may, but need not, entail a lapse in consciousness. A self-awareness deficit could presumably occur, for example, during an immersive, highly engaging experience that promotes 'flow' or 'dissociation', such as during gambling [60]. (iv) Scope: interoception and alexithymia are probably most closely related to our concept of self-awareness. However, our formulation goes beyond awareness of bodily sensations (interoception) or emotions (alexithymia) to also include awareness of ongoing behavior and its designation as important to the self.

Linking personal relevance with self-awareness in psychopathology

Compromised self-awareness in psychopathology may be driven by disorder-specific abnormalities in the rACC/vmPFC [4]. When individuals with schizophrenia reflected on themselves, contrasted with when they reflected on others, a correlation emerged between vmPFC activation and better cognitive insight, as measured by self-awareness that one's strange mental experiences may have been fictitious [19]. In Alzheimer's disease, patients with more self-awareness of their illness-related deficits showed more rACC/vmPFC activity during a go/no-go task than those with less self-awareness [20]. Patients with lesions to the vmPFC overestimate their own ability, compared with informants' ratings, to self-monitor their own behavior and adaptively adjust their actions [21].

This framework may also extend to depression and anxiety disorders. In an interesting dissociation that underscores the role of the rACC in tagging information

as personally relevant, depressed participants had increased rACC activation during inhibition of negative, but not positive, words [22]. In another dissociation, healthy controls and individuals with social phobia (who fear being negatively evaluated by others) were exposed to evaluative phrases that were presented either in the first person (e.g., 'I'm ugly') or in the second person (e.g., 'You're ugly'). Healthy controls had higher vmPFC activity during first- versus second-person phrases, whereas individuals with social phobia had higher vmPFC activity during the reverse contrast [23] – presumably of high personal relevance to this psychopathology.

Neural correlates of self-awareness in drug addiction**Increased rACC/vmPFC activity to drug-related stimuli**

In drug addiction, one could expect similarly increased rACC/vmPFC activation to addiction-associated cues, which are likely to be tagged with high personal relevance. Recent neuroimaging meta-analyses of multiple

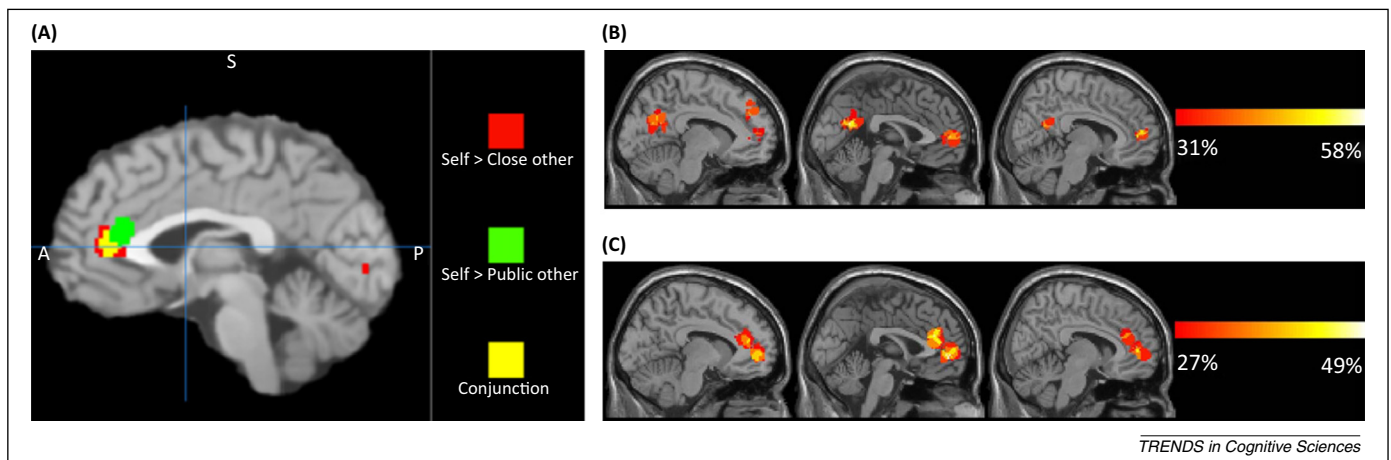


Figure 1. Converging meta-analyses showing the rostral anterior cingulate cortex/ventromedial prefrontal cortex (rACC/vmPFC) association with personal relevance in health. Across multiple functional MRI (fMRI) studies, research points to a self-to-other gradient that extends along the midline from ventral PFC to dorsal PFC, with the more ventral PFC regions responding more preferentially to self-processing (and very close others). For example, the rACC is activated to the contrasts (A) self>close other, self>public other, and their conjunction (adapted, with permission, from [61]); and (B, C) self-reflection>baseline and self-reflection>other-reflection, respectively (adapted, with permission, from [4]).

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