



Opinion

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Addiction as a Disruption of the Markov Blanket: A Hyper-Precision of Momentary Rewards Over Long-Term Adaptation



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Abstract

This opinion piece proposes that addiction can be conceptualized as a disruption of an agent's Markov blanket - the statistical boundary separating internal states from the external environment - under active inference. Addiction arises when the Markov blanket becomes overly rigid, assigning excessive precision to a narrow set of sensory inputs and active states associated with the addictive stimulus. This leads to compulsive behaviors aimed at immediate rewards while sacrificing the exploration of flexible action policies that would reduce uncertainty and optimize the agent's long-term fit with the environment. The addicted agent becomes trapped in a limited behavioral repertoire, unable to adapt to volatility, thus eroding its own resilience. Rigid, compulsive patterns of interaction can propagate outwards, undermining the resilience and sustainability of the wider ecosystem. This perspective offers an integrative framework for understanding addictive disorders and their broader impacts, suggesting interventions aimed at pulling the Markov blanket away from problematic attractors and promoting adaptive exploration.

Keywords: Addiction; Active Inference; Resilience; Sustainability; Super stimuli

Opinion

Recent advances in applying active inference and Markov blanket formalisms to understand cognition and behavior are a possible pathway for reconceptualizing addiction. I propose, in line with the work of Miller, Kiverstein [1] and Schwartenbeck [2] over the last ten years, that addiction can be characterized as a disruption of an agent's Markov blanket, leading to an inability to flexibly adapt to the environment and minimize free energy over extended timescales. Rigidity reduces the agent's resilience to volatility and potentially undermines the resilience and sustainability of their local ecosystem [3,4].

Under active inference, agents maintain their structural and functional integrity by minimizing variational free energy - the difference between their internal generative model of the world and actual sensory inputs. Agents can do this by updating their beliefs, and thus changing their perceptions. And they can also do this by sampling the environment to generate sensory inputs that match predictions, which is taking action. The Markov blanket is the statistical boundary that separates an agent's internal states

from the external environment, consisting of sensory and active states that mediate this interaction [5].

In a healthy, adaptive agent, the generative model and resulting action-perception cycles enable exploration of the "fitness landscape" - the space of policies (action sequences) that lead to valuable, uncertainty-reducing states over multiple spatiotemporal scales [4]. This entails a delicate balance of precision weighting - the confidence or salience assigned to prediction errors that drive belief updating and policy selection [6].

In this formulation, addiction arises when the Markov blanket becomes overly rigid and impermeable, assigning exceedingly high precision to a narrow set of sensory inputs and active states associated with the addictive stimulus or behavior [2]. This creates a positive feedback loop where strong prior beliefs about the rewarding nature of the stimulus generate equally strong prediction errors when it is absent, driving compulsive behavior to resolve this discrepancy.

Addiction can be characterized as a failure of inference and consequent learning, where false inference leads to a failure to learn the negative consequences of action and update higher levels of the generative model accordingly. The addicted agent becomes trapped in a limited repertoire of strategies to regulate its internal states, decoupled from the wider context and unable to discover new approaches. This hyper-precise focus on immediate sensory rewards comes at the expense of exploring alternative action policies that may reduce uncertainty and improve the agent's model of its embodied state in the environment over longer timescales. The narrowing of the agent's exploratory scope reduces its resilience to unexpected perturbations or volatility in the environment, as it lacks the flexibility to adapt its model and behavior to changing circumstances [4].

The addicted agent's rigid, compulsive patterns of interaction with its environment can lead to the depletion of resources. It disrupts their ecological balance, which can over time undermine the sustainability of the wider system [3]. For instance, substance addictions often drive behaviors that strain social relationships, financial stability, and physical health, creating cascading negative impacts [1]. Similarly, behavioral addictions to digital media can lead to neglect of real-world interactions and responsibilities, eroding the social fabric [7].

This perspective aligns with observations that addiction hijacks the brain's reward learning system. Addiction narrows behavioral repertoires to hyper-focus on cues and actions related to the addictive target [8]. As Friston et al. [6] propose, addictive substances directly drive dopaminergic responses that normally encode the salience of stimuli for reducing uncertainty. Over time, the brain learns to expect (and require) these powerful yet artificially induced neurochemical effects, entraining strong cyclic behaviors.

Markov blanket disruption can cast substance addictions, but it can also encompass addictive behaviors and relationships with non-drug rewards. For instance, the design of digital media platforms exploits natural attentional dynamics to create "super stimuli" that progressively capture agent's action perception cycles in compulsive, reward-seeking loops [7]. The resulting patterns of heightened salience, anticipation, and compulsive engagement parallel substance addictions.

The distortions of salience and belief updating process characterizing the addictive process impair agents' abilities to flexibly modulate their internal states and interface coherently with the world. This manifests as disrupted attention, low engagement and motivation, and an inability to explore adaptive behaviors focused on larger contexts - all commonly observed

in addiction [9], but more generally becoming part and parcel of the way we engage with the world, as the world is shaping our perceptions and our affordances [10,11].

Recasting addiction as the entrenchment of an agent's Markov blanket around a highly-weighted yet narrow set of sensory states and active policies helps us tackle addictive disorders across multiple scales. Rigidity erodes the agent's resilience to volatility but can also propagate outwards to undermine the resilience and sustainability of the wider system. Interventions meant to pull the agent towards an ability to explore the broader fitness landscape may help restore flexible, uncertainty-reducing engagement with the environment, alleviating their possible issues with the ecosystem, and alleviating the strain they may be causing to their immediate landscape. Future theoretical and empirical work is needed to fully translate this perspective into measurable psychophysiological processes and clinically meaningful strategies.

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