# Commentary

# Addicted to Habits or to Sense of Control?

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As recently suggested by Berridge (1), "it might be valuable to explore alternative concepts for actions in addiction," notably regarding the nature and the role of so-called drug-cue–driven habitual actions. The study by Fouyssac *et al.* (2) in the current issue of *Biological Psychiatry* is in line with this suggestion. Fouyssac *et al.* (2) present a compelling and comprehensive set of behavioral and neurobiological data supporting an original mechanism, in which habit-based seeking actions for cocaine become reinforcers on and by themselves, and in which preventing them from being expressed would generate distress resulting in an urgency to act and in increased risk of relapse.

Emotional states and drug cues can promote relapse, both independently and also through intertwined interactions. Positive and negative emotional states can by themselves precipitate relapse, notably in patients with a tendency to respond impulsively to extreme affective states. It is widely understood that positive emotional states can be triggered by drug-paired cues. Although drug cues can also evoke negative emotional states, relapse promoted by negative emotional states is usually attributed to stress or drug withdrawal. As Fouyssac *et al.* (2) point out, the psychobiological mechanisms of relapse triggered by drug-cue–evoked negative emotional states are not well understood.

In this study, forced abstinence from cocaine self-administration in the rat results in a postabstinence rebound in seeking behavior. This rebound is observed specifically in rats trained to self-administer cocaine in a second-order schedule of reinforcement (SOR), in which drug cues promote and support dorsolateral striatum–dependent habit-based cocaine seeking. By itself, however, the rebound appears to be goal directed, being dorsolateral striatum independent. Also critically, it is independent of drug withdrawal. Indeed, cocaine delivery during the behavioral abstinence period does not prevent the rebound of seeking. The urgency to seek is not induced by re-exposure to the drug-associated cue, however. Indeed, the delivery of the drug cue is unnecessary for the behavioral rebound to manifest.

This study raises several interesting questions. One of them is whether habit-based actions' becoming positive reinforcers, on and by themselves, whose abstinence generates a behavioral rebound is drug specific or is independent of the nature of the reinforcer that has initiated these habits. The rat model of negative urgency by Bardo *et al.* (3), in which excessive seeking is generated by unexpected omission of a natural reward, supports the latter idea.

Data from Fouyssac *et al.* (2) suggest that rats trained for cocaine in a SOR might not all be equally responsive to abstinence. Studying the individual variations in this behavioral rebound to abstinence—and in particular how these variations relate to expression of distress and to an impulsive state or trait—would be an interesting follow-up. This would be a relevant angle to test their hypothesis that the rebound of behavior they observed in SOR-trained rats is indeed driven by negative urgency, i.e. the tendency to respond impulsively to extreme negative affective states.

Further following the suggestion by Berridge (1) to explore alternative concepts for actions in addiction, I propose a complementary interpretation and perspective to the observations by Belin's laboratory. Notably, it might be of interest to consider that through habits, a SOR engages the sense of agency and fosters a sense of control, the abstinence from which would generate distress and an urge to re-exert control.

The sense of agency, defined as the experience of controlling one's own action and, through them, the course of events in the outside world, has been linked to mental and neurological disorders when altered, and is enhanced by alcohol in healthy humans (4).

Grounded on the sense of agency, the sense of control over actions is a reward in itself (5), whose adaptive role as a natural reinforcer would be to improve one's ability to influence the environment, together with reducing uncertainty. Preferentially attributed to humans, maybe because they have many more opportunities to exert it, the sense of control might well be present and adaptive in animals, including laboratory rodents. Notably, exerting control over stressful situations is protective and reduces distress in laboratory rats (6).

Baptista *et al.* (7) note that the current cognitive model distinguishes between an implicit and an explicit sense of agency. The implicit sense of agency is mediated by lower-level prereflective sensorimotor processes and depends on the monitoring of internal signals and external cues, such as sensory inputs from the environment (7), and could well be supported by habit-based actions in a SOR. Beyond the sense of agency, habits might well foster a sense of control. Indeed, one of the mechanisms through which habits are believed to endorse motivational and reinforcing properties is by providing control feedback (8). Thus, it might well be of interest to consider that a SOR fosters a sense of control, the abstinence from which generates distress and negative urgency.

A final, burning question is how the mechanism identified by Fouyssac *et al.* (2) relates and contributes to addiction vulnerability. How do sensitivity to the putative reinforcing properties of habit-based actions and sensitivity to distress provoked by abstinence contribute to the development of maladaptive seeking? This is a complex question to answer, in particular considering another recent study from Fouyssac *et al.* (9) in which Belin's laboratory demonstrated that the living conditions of rats influence how behavioral vulnerability traits

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determine vulnerability to make the transition from a controlled to a cocaine or alcohol addiction-like behavior. In this context, it is interesting to note that living conditions can affect the prereflective sense of agency (10).

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