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Compulsivity in obsessive-compulsive disorder and addictions

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Abstract
Compulsive behaviors are driven by repetitive urges and typically involve the experience of limited voluntary control over these urges, a diminished ability to delay or inhibit these behaviors, and a tendency to perform repetitive acts in a habitual or stereotyped manner. Compulsivity is not only a central characteristic of obsessive-compulsive disorder (OCD) but is also crucial to addiction. Based on this analogy, OCD has been proposed to be part of the concept of behavioral addiction along with other non-drug-related disorders that share compulsivity, such as pathological gambling, skin-picking, trichotillomania and compulsive eating. In this review, we investigate the neurobiological overlap between compulsivity in substance-use disorders, OCD and behavioral addictions as a validation for the construct of compulsivity that could be adopted in the Research Domain Criteria (RDoC). The reviewed data suggest that compulsivity in OCD and addictions is related to impaired reward and punishment processing with attenuated dopamine release in the ventral striatum, negative reinforcement in limbic systems, cognitive and behavioral inflexibility with diminished serotonergic prefrontal control, and habitual responding with imbalances between ventral and dorsal frontostriatal recruitment. Frontostriatal abnormalities of compulsivity are promising targets for

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neuromodulation and other interventions for OCD and addictions. We conclude that compulsivity encompasses many of the RDoC constructs in a trans-diagnostic fashion with a common brain circuit dysfunction that can help identifying appropriate prevention and treatment targets.

1. Introduction

Compulsivity in obsessive–compulsive disorder (OCD) is related to the feelings of limited voluntary control and being compelled to perform repetitious, self-defeating behaviors (Denys, 2011; Robbins et al., 2012). Based on analogies between these compulsive characteristics of OCD and the cognitive and behavioral characteristics of substance-use disorders, some researchers have proposed to view OCD as a behavioral addiction (Holden, 2001; Denys et al., 2004), together with several other non-substance disorders, including pathological gambling, trichotillomania, skin-picking, compulsive eating, compulsive computer use, compulsive sexual behavior, and compulsive buying (Holden, 2001; Grant et al., 2006). The study of different aspects of compulsivity and their neural correlates in these disorders may help to test the behavioral-addiction paradigm and to define shared brain networks.

In OCD, compulsivity represents a key symptom. Although patients suffering from OCD may present with various types of obsessions and compulsions that may be accompanied by other symptoms such as anxiety and depression, a compulsive drive with a perceived loss of control appears to be a crucial factor.

In addiction, two theories describe the development from initial (impulsive) drug use to chronic (compulsive) drug taking. One theory forwarded by Everitt and Robbins (2013) emphasizes the progression from initial action-outcome (reward-based) learning to stimulus-response (habitual) learning. Another theory forwarded by Koob and Le Moal (2005) emphasizes the transition from positively reinforced drug-taking (impulsive stage) to negatively reinforced (removal of aversive state) compulsive drug-use (compulsive stage). These theories are not mutually exclusive, but they do suggest different processes in the development of compulsivity.

In behavioral addictions, compulsivity is less well studied, especially compared to other relevant constructs such as impulsivity. On the 1st of May 2015, the search terms compulsivity and behavioral addiction resulted in 68 Pubmed listings, whereas the terms impulsivity and behavioral addiction resulted in 6268 listings.

Like impulsivity, compulsivity may be decomposed into various factors with a mainly cognitive, affective or motivational nature. First, compulsivity, as engagement in self-defeating repetitive behaviors, hints at impaired reward and/or punishment processing. Second, the diminished ability to stop or divert unwanted ideas and actions suggests the presence of cognitive and behavioral inflexibility. Third, habitual responding and diminished goal-directed control suggests excessive habit-learning. In this narrative review, we will study the neural overlap of these different aspects of compulsivity in OCD, substance-use disorders and behavioral addictions, including human imaging studies and animal models of compulsive behavior and associated neurotransmitters. Our goal is to use these data to define which neural processes are central to compulsivity and to use this knowledge as a pathophysiological validation for the possible adoption of compulsivity in the Research Domain Criteria (RDoC; Insel et al., 2010; Casey et al., 2013).

2. Neurocognitive factors

2.1. Reward processing

Compulsivity in OCD and addiction may in part be explained by dysfunctional brain reward systems, driving the development of a restricted behavioral repertoire at the cost of healthy rewarding actions and a relative failure to switch to more adaptive, goal-directed behaviors. Indeed, patients with OCD displayed attenuated reward anticipation activity in the ventral striatum compared to controls (Figee et al., 2011, 2014), which matches blunted reward anticipation signals of the ventral striatum in alcohol (Wrase et al., 2007), nicotine (Martin-Soelch et al., 2003; Bühler et al., 2009) and cannabis dependence (Van Hell et al., 2010) in a behavioral addiction like pathological gambling (Reuter et al., 2005; De Greck et al., 2010; Balodis et al., 2012; Choi et al., 2012), and in binge-eating disorder (Balodis et al., 2013). However, not all studies of substance-use disorders and behavioral addictions show this pattern. For example, mixed findings were reported in cocaine dependence (Balodis and Potenza, 2015) and pathological gambling (Van Holst et al., 2010, 2012a, 2012b). Blunted striatal responsiveness in OCD is paralleled by increased striatal activity in response to symptom-provoking stimuli (Menzies et al., 2007; Rotge et al., 2008), which appears to be analogous to ventral striatal hyperactivation associated with disorder-specific stimuli in drug addiction (Wrase et al., 2007; Diekhof et al., 2008; Kühn and Gallinat, 2011). Similar findings have been observed in some (Hollander et al., 2005; Van Holst et al., 2012a, 2012b), but not all (Potenza et al. 2003) studies of pathological gambling and may also hold true for food consumption and weight gain (Stice et al., 2010). This suggests that the ventral striatum may be less responsive when recruited for healthy reward processing due to its bias toward drugs in addiction, and due to its bias to disease-specific stimuli in OCD and behavioral addictions. Importantly from a treatment perspective, effective deep-brain stimulation (DBS) for OCD has been related to a normalization of anticipatory reward responses in the ventral striatum (Figee et al., 2014).

It should be noted that there are also diverging reward-processing findings. First, some studies showed no blunted