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Interventions aimed at automatic processes in addiction: considering necessary conditions for efficacy

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Automatic processes related to addiction can be directly targeted in novel training paradigms. First studies have demonstrated that Cognitive Bias Modification (CBM) targeting approach biases can enhance treatment outcomes when added to regular treatment. However, the overall efficacy of CBM is debated. We argue that considering the modulating role of motivation and the mediating role of actual bias change are essential to drawing valid conclusions. Findings on mediating cognitive and neural mechanisms underlying clinical effects provide further sources of evidence on CBM. Taken together the literature supports the claim that cognitive bias change can improve clinical outcome, but that there are necessary conditions that must be met. Improved theoretical understanding of changing biases and new techniques such as neuromodulation may be needed to optimally apply CBM to help patients overcome addictive behavior.

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Introduction

Theories of addiction range from considering it a moral failure [1,2•] to a brain disease [3,4]. Essentially, the role of agency varies in these accounts [5]. Does one choose to use drugs, despite personally and socially harmful consequences, for selfish reasons? Or is the brain of an addict compromised, rendering them unable to control their drug seeking and consumption? Such contradictory views are a problem, as they suggest quite different kinds of intervention. Dual-process models of addiction [6,7] resolve this conflict by understanding choice itself as an emergent brain function — the outcome of interactions between fast automatic processes underlying impulsive behavior versus slow reflective processing allowing self-regulation [8,9]. Neurobiological consequences of drug use [10] may well lead to involuntary automatic responses involving drug cues, but the ultimate impact of these effects on behavior is modulated by higher-order reflective cognition. Such models also have implications for interventions. First and foremost, they suggest the use of techniques collectively termed Cognitive Bias Modification (CBM).

CBM for addiction

A cognitive bias is a difference in the automatic processes evoked by a certain class of stimuli. Such biases can be related to a psychiatric disorder, such as anxiety [11] or addiction [12]; motivational states such as hunger [13]; training [14]; or expertise and interest (e.g., car-lovers quickly spot a rare sports-car). Importantly, in relation to psychiatric disorders, these biases contribute to the etiology and maintenance of the disorder [15]. An illustration of this is a problem drinker who may have good intentions to cut down drinking for various long-term reasons, such as health and relationship problems, but a conditioned alcohol-related stimulus is likely to catch the eye (attentional bias), bring to mind tempting memories of fun or reduced stress (association activation), and increase the likelihood of actions aimed at alcohol consumption (approach bias) [16]. Hence, these biases may contribute to continued drinking or other addictive behaviors despite explicit intentions. Where such automatic processes play a role, CBM may help patients to remain abstinent [17].

The bias that has shown the most promising results in CBM is the tendency to approach addiction-related stimuli. Wiers, Rinck and colleagues first developed a task to indirectly assess this bias [18], in which heavy drinkers showed an approach bias for alcohol-related stimuli, moderated by the presence of a g-allele in the OPRM1 gene (previously related to cue-induced craving). Participants were requested to pull or push a joystick in response to the format of a picture (e.g., push landscape pictures, pull portrait pictures), which was followed by a zoom-mechanism contingent upon the movement (zoom in after pushing the joystick, zoom out after pulling), creating a sense of avoidance or approach, respectively. A first proof-of-concept study in students demonstrated that this bias could be changed, with generalization to untrained pictures and to drinking behavior in a taste-test [19]. In a first randomized clinical trial (RCT), patients

received four sessions of approach-bias retraining or placebo-training (continued assessment) or no training. Training changed the approach-bias more strongly than the control conditions, with generalization to untrained pictures and related verbal memory-associations. Moreover, trained patients were less likely to have relapsed a year after treatment discharge [20••]. In a recent large RCT, this effect on relapse was replicated, and was found to be mediated by the change in approach-tendencies [21•]. A very recent study has reported positive findings for approach bias retraining during detox [22].

Another common target for CBM is the attentional bias, which can be targeted for retraining using similar variations of assessment tasks such as the dot-probe task [23]. A first small clinical Randomized Controlled Trial has provided preliminary evidence that this may be effective in alcoholic patients [24] and a larger replication is underway. Other methods have shown promise in changing biases in heavy drinking students; for example, evaluative conditioning [25], interpretation bias modification [26], and response inhibition training [27]. However, clinical effects of these variants of CBM remain to be established. Further, many published results in healthy subjects involve exploratory analyses, or some degree of uncontrolled multiple testing [28], and require replication.

Working memory training for addiction

Although CBM for addiction is aimed at changing automatic processes, dual-process models suggest that improving cognitive control might also help individuals to regulate their behavior in the face of dysfunctional biases [29]. Working memory training has been applied with some success to addiction [30,31,32•]. The first study [30] found reductions in alcohol consumption in problem drinkers, but only in those who demonstrated relatively strong positive alcohol associations. Bickel and colleagues [31,32•] found that working memory training in stimulant addicted patients has an effect on delay discounting, a facet of impulsivity associated with addiction. However, results of cognitive control training in addiction are quite preliminary at this stage. We briefly note that game-versions are being developed to reduce the problem of working memory training being extensive and boring, but it is not yet clear how well such approaches will work [33•].

The efficacy debate: motivation, mediation and variations

Various papers have argued that the evidence for CBM, or specific CBM variants, is weak [34,35]. Responses to this claim [17,36••] have made two particular important counter-arguments, both of which are in line with our theoretical basis in dual-process models.

First is that CBM can only be evaluated in the context of effective motivation: Without adequate motivation-to-change and associated goals and strategies at the level of reflective processing, no effect of CBM can be expected. Note that it is a crucial ingredient of many interventions in addiction to help people develop a long-term perspective, including personal goals that conflict with continuation of the addictive behavior [37,38]. This is exemplified in the motivational interviewing approach, a therapeutic technique originally developed by Bill Miller in the context of addiction treatment, and now applied more widely [39]. For example, a recent study found initial evidence that change talk — speech expressing motivation to reduce usage — in adolescents (elicited with motivational interviewing techniques) and its neural correlates predicted prospective marijuana use [40]. Note that in the RCTs for CBM discussed above [20••,21•,24], training was added to regular treatment, in which motivation to change is enhanced and the patient is helped to develop an alternative long-term perspective. In line with the idea that motivation is a necessary condition for a positive outcome, CBM has demonstrated no effect in participants who were not motivated to change [41], self-selected problem drinkers with uncertain motivation to change [42] (although all groups including the control group did reduce their drinking), or community smokers not wanting to quit smoking [43•]. Promisingly, however, a recent online study on smoking only required smokers to make an actual quit-attempt to be included and found increased chance of abstinence half a year later (in heavy smokers only) in the training group compared to the control group [44•].

Second, if the rationale for CBM is correct then clinical change is mediated by changes in bias. If an intervention fails to change the targeted bias, then a lack of clinical effects cannot be taken as evidence against CBM. The only conclusion that can be drawn is that the particular method did not, in fact, modify a cognitive bias. The pattern of results over studies shows that studies with clinically relevant effects almost always show a change in cognitive bias, while negative studies do not [36••,45]. This pattern is just what would be expected if cognitive biases play a causal role in outcome. Note that various mediating biases have been found for the approach bias retraining [20••,21•,46•].

Analyses that fail to consider these factors might lead to invalid or less relevant conclusions. A more general point about pooling results is that the existence of some effective forms of CBM does not imply that every attempt is likely to be successful. It may be more useful at this stage to try to answer less generalizing questions such as: What makes which methods more or less effective; which conditions are necessary; and what are the mechanisms underlying effects?

New developments in theory and methods

We are only beginning to learn about the underlying neurocognitive mechanisms of CBM [47]. Regarding

cognitive mechanisms, clinical effects in approach-bias retraining are mediated by alcohol-related action tendencies and avoidance associations [21•,46•], and it was also found that patients with a strong approach bias profited most from CBM as a supplement to therapy [21•]. Only a few studies have been published on the neural mechanisms of CBM in addiction. Corinde Wiers and colleagues [48••] found that alcohol approach-bias retraining CBM reduced alcohol cue-evoked activation in amygdala and nucleus accumbens in a passive viewing task. Reduction in amygdala activation was associated with reduction in craving within the CBM group. In an approach-bias assessment task in the scanner, CBM was found to decrease medial prefrontal cortex activation [49•], an area previously related to an alcohol-approach bias [50,51]. Note that such results provide convergent evidence that CBM can affect at least certain neurocognitive processes.

Understanding these mechanisms depends on our theoretical foundations. Recent theoretical criticisms of dual-process models are therefore highly relevant to CBM. Models that posit or imply dual systems have been argued to have theoretical problems, as arguments for clearly distinguishable systems or types of process appear to be flawed [52]. For instance, there does not appear to be a neurobiological basis for dual systems despite interesting early models [53]; for example, subcortical regions attributed to the reflexive system also play a role in working memory [54]. Further, systems with disjunctive sets of functions run into difficulties when, logically, these functions must be integrated and work together somehow. If 'hot' motivational and emotional functions are assigned to an impulsive system, for example, then a problem termed the motivational homunculus occurs: Why does the reflective system exert control in line with the individual's goals and motivation? One solution to such conceptual problems was proposed via the R^3 model [8,55], which focuses on generalized response selection mechanisms, emphasizing iterative processes with varying temporal dynamics [56], consideration of the levels of description of different concepts, and the reinforcement of covert cognitive functions [57]. The model supplies a proof-of-principle definition of a continuum of automatic versus reflective processing, in terms of how much evaluation precedes selection. This avoids the above theoretical problems while retaining the useful heuristic of automatic versus controlled processes and relatively impulsive versus reflective behavior. Further, more specific research continues on automatic processes and implicit measures involved in addiction. For instance, temporal dynamics [58,59] and trial-to-trial fluctuations [60,61] appear to play a role in attentional biases. Such research is particularly relevant in terms of finding novel targets for CBM, although current methods appear to remain focused on simple biases.

An improved grasp of neurocognitive mechanisms in CBM may also inform the use of neuromodulation methods such as transcranial Direct Current Stimulation (tDCS) or repetitive Transcranial Magnetic Stimulation (rTMS) [62]. Although generalizations about its efficacy are debated [63•,64], prefrontal tDCS has been found to improve working memory [65,66], facilitate the training of cognitive skills [66,67] and reduce cue-evoked craving for various addictive substances [68–70]. This suggests various mechanisms by which tDCS could interact with CBM. The cognitive state of participants could be made more amenable to addiction-related training, either via reflective (improved working memory) or impulsive (reduced craving) pathways, or general neural learning mechanisms could be modulated [71]. Two attentional bias modification studies have indeed shown such enhancement concerning attention to threatening stimuli [72•,73]. Analogous applications of tDCS in addiction CBM are to our knowledge yet to be published, but in our lab studies are underway with promising results. Note that the essential point here is that tDCS by itself is not expected to have persistent effects: It is expected to enhance training effects.

Finally, it is an interesting question to what extent treatment can be provided with a minimal face-to-face protocol [74], or perhaps even automated and online, which has proved to reduce problem drinking by itself [75]. Such interventions could easily be supplemented with online training [76]. Rapidly developing technological possibilities will permit further tailoring of cognitive training to the individual, making it more personally salient, and permit mobile interventions that occur in situations relevant to the bias being trained [28].

Conclusions

Targeting automatic processes may be an important piece of the puzzle of effective treatment for addiction, and complementary methods focused specifically on these processes could improve outcome for some patients. Training and neuromodulation may reduce impulsive tendencies or help patients to overcome them, but alternative choices and long-term perspectives that are incompatible with continuation of the addictive behavior appear necessary to profit from training effects [77•,78]. Further, a CBM intervention must actually change a proximal bias to be expected to have distal effects on clinical outcome. Much work remains to be done to determine the most relevant biases to target, and the most effective training tasks for those biases. Research therefore needs a healthy combination of exploratory studies, aimed at finding relationships between biases and symptoms and between training variants and changes in biases; confirmatory RCTs testing clinical effects of the most promising variants; and meta-analyses on appropriate subsets of confirmatory studies, taking into account theoretical considerations.

Conflicts of interest

Nothing declared.

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