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SUBSTANCE USE AND RELATED DISORDERS (JR MCKAY, SECTION EDITOR)

New Developments in Behavioral Treatments for Substance Use Disorders

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Abstract After decades of defining which behavioral treatments are effective for treating addictions, the focus has shifted to exploring how these treatments work, how best to disseminate and implement them in the community, and what underlying factors can be manipulated in order to increase the rates of treatment success. These pursuits have led to advances in our understanding of the mechanisms of treatment effects, the incorporation of technology into the delivery of current treatments and development of novel applications to support relapse prevention, as well as the inclusion of neurocognitive approaches to target the automatic and higher-order processes underlying addictive behaviors. Although such advances have the promise of leading to better treatments for more individuals, there is still much work required for these promises to be realized. The following review will highlight some of these recent developments and provide a glimpse into the future of behavioral treatments.

Keywords Behavioral treatment · Substance use disorders · Mechanisms · Evidenced-based therapy · Contingency management · Cognitive–behavioral therapy · Brief interventions · Mindfulness-based relapse prevention · Technology-based interventions · Neuroscience-based interventions · Neurocognitive function · Cognitive enhancement

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Introduction

Despite advances in pharmacotherapies over the last few decades, behavioral treatments remain an important component, and often the only evidenced-based component, for the treatment of various substance use disorders. Well-established behavioral treatments, such as cognitive–behavioral therapy (CBT) and contingency management (CM), have continued to demonstrate effectiveness, through randomized controlled trials, in reducing substance use in a range of populations. Despite this established efficacy, the considerable cost and resources needed for successful implementation have served as a significant roadblock to broad dissemination. Recent efforts at disseminating these evidenced-based approaches have incorporated advances in technology, as computer- and mobile-based delivery of behavioral treatments offer the potential for a cost-effective and easily distributed treatment. As such, many new technology-based versions of these behavioral treatments have appeared in recent years, with some promising effects, yet this area is still largely underdeveloped.

Furthermore, the last decade has seen a shift in focus from establishing evidence of efficacy, toward determining moderators and mechanisms by which the effect operates. Answering the questions of *how* and *when* a treatment works can lead to more effective treatments for more people. This focus shift in research has led to advancement of our understanding of the neurocognitive mechanisms of addiction recovery, resulting in the inclusion of cognitive neuroscience-based interventions to supplement standard behavioral therapies. Although there has been strong empirical evidence regarding the neurocognitive effects of drug and alcohol use for quite some time (e.g., [1] and [2]), evidence of a direct effect of cognitive impairment on treatment outcomes has been mixed, and until recently, applications toward developing more effective treatments have lagged behind

[3••]. However, there has been a recent surge in novel interventions that target executive control and/or underlying automatic cognitive processes as a method for facilitating avoidance of drug/alcohol use.

The following sections provide a review of the recent developments among behavioral treatments for alcohol and drug use disorders that have been found effective in multiple randomized clinical trials, with special emphasis on dissemination/implementation issues, and the treatment's hypothesized mechanisms of action. Interventions that have incorporated technology-based delivery will also be highlighted, as well as the latest evidence regarding neuroscience-based interventions for targeting cognitive processes.

Advances in Evidenced-based Therapies

CM

CM, in which patients receive incentives or rewards for meeting specific behavioral goals (e.g., verified abstinence, treatment attendance), is among the most efficacious behavioral treatments for substance use disorders [4, 5]. Recent studies have extended the evidence to additional populations, such as veterans [6], non-maintained opioid-dependent patients [7], homeless men who have sex with men [8], and those with co-morbid mental health disorders [9], to name a few. Importantly, the effects of CM have been found to extend beyond mere reductions in substance use, as recent findings have also indicated reductions in psychiatric symptoms [10, 11•]. Despite the strong evidence of the effectiveness of CM, it remains rarely implemented in clinical practice. Various reasons have been cited, such as the perceived cost of incentives, the problematic implementation in group settings, the return to baseline substance use rates once the reinforcers are no longer provided, and therapists' beliefs regarding empirical support [12–14].

With a goal of broad dissemination, there have been considerable efforts made to address these concerns. The "fishbowl" technique, developed a decade ago by Petry [15–17] to reduce cost by using a variable ratio reinforcement schedule of prizes, has become more prevalent in studies evaluating "prize-based" CM. Several studies have manipulated the monetary amount of reinforcement, with most indicating higher magnitude reinforcement being more effective than lower magnitude, especially for those initiating treatment with a positive urinalysis [18, 19•]. Furthermore, because frequent urinalysis testing significantly adds to the implementation costs of CM, efforts to reinforce treatment attendance have been examined, with some evidence of effectiveness for those who are abstinent upon initiation of treatment [19•]. Recently, a novel adaptation of group-based CM, wherein patients earned chances to have their name drawn from a hat as a way to earn prizes based on group attendance and evidence of drug abstinence, was found to be effective at increasing attendance and drug abstinence relative to standard care [20]. Such evidence further supports the use of CM in a group context, making the intervention more consistent with the mode of treatment offered at most community clinics.

Recent efforts to address the lack of durability of CM have included increasing the duration of CM so that clients will attend treatment for longer and achieve longer periods of consecutive abstinence, thereby increasing the chances of maintaining abstinence after treatment [21], and combining CM with other psychosocial treatments that have established durability, such as CBT (e.g., [22] and [23]). CM also has benefits when combined with pharmacotherapies, and has become the platform intervention of choice in randomized trials of new pharmacotherapies for drugs of abuse owing to its positive effect on medication adherence [24, 25]. However, durability and the transportability of CM into community practice continues to be challenging and remains an important topic [26].

As evidence of efficacy has clearly been established for CM, there has been relatively little focus on the question of *how* it works (i.e., mechanisms of action), until recently. While some earlier efforts to identify the mechanism of the effect of CM highlighted the role of increasing patient self-efficacy for those receiving CM [27], a more recent focus has been placed on decision-making and the potential that changes in delay discounting act as a mediator of outcomes [28]. Substance users are faced with many decisions throughout their daily lives regarding the choice of an immediate reward (e.g., drug use) versus a more delayed reward (e.g., benefits of abstinence); the phenomenon of delay discounting is the tendency to undervalue (i.e., discount) the future (i.e., delayed) rewards relative to immediate rewards [29]. CM may affect this decision-making process by shifting the preference from the immediate rewards of drug use to the delayed reward of abstinence (by providing a briefer delayed reward such as prizes or vouchers). Although the evidence is limited, changes in delay discounting have some promise as one of the mechanisms by which CM serves to reduce substance use and achieve/maintain abstinence [28, 30•]

CBT

CBT is another well-established evidenced-based treatment for substance use disorders, with demonstrated effectiveness in a range of studies over the last two decades. Multiple meta-analyses have reported small, but significant, effects of CBT at reducing substance use rates across a variety of substances of abuse, with the largest effects found for marijuana and cocaine use [4, 31]. Although CBT has some advantages over CM in terms of its durability, with effects maintained, and in some

cases strengthened, following treatment termination (i.e., "sleeper effect"), it also faces criticisms, such as the mixed effect on early retention in treatment and limited focus on patient motivation and engagement, as well as the challenges of implementation within community clinics. Combining CBT with either CM or motivational enhancement therapy (MET) is one approach to address these weaknesses, yet the results have been mostly mixed [22, 23, 32, 33].

Rather than addressing motivation, more recent efforts to address engagement and improve outcome have targeted clients' cognitive function, as several studies have found poorer cognitive functioning associated with earlier treatment dropout [34], fewer skills acquired [35], and poorer substance use outcomes [36–38]. CBT is considered a cognitively demanding treatment, and often individuals entering treatment present with cognitive deficits; multiple studies and meta-analyses have reported the association between chronic alcohol/drug use and deficits in cognitive function [2, 39–42]. These include deficits in decision-making, response inhibition, planning, working memory, and attention—areas of executive function important for acquiring and implementing complex coping skills taught in CBT for substance use disorders. Therefore, interventions designed to target and improve these areas of cognitive function would theoretically improve the ability to avoid substance use and acquire coping skills to maintain abstinence. Cognitive enhancing interventions, such as computerized cognitive remediation, as well as newer pharmacologic agents, have recently gained greater attention as potential treatment targets and/or adjuncts to CBT [43].

Although cognitive remediation interventions have been found effective at improving cognitive function among schizophrenic populations for quite some time [44], the evidence of its effectiveness among substance use disorder populations has been fairly mixed over the last 15 years. Recently, there has been a surge in interest in this area, as studies have suggested cognitive training can improve certain neurocognitive processes in substance users (e.g., working memory [45, 46•]) and improve non-cognitive outcomes when combined with CBT [47]. Another method gaining greater attention for improving cognitive functioning is by pharmacological treatments. There are several promising cognitive-enhancing pharmacotherapies for addictions [43]; however, very few have been investigated in combination with CBT. Our group currently has a randomized trial underway evaluating the benefit of adding galantamine, an acetylcholinesterase inhibitor, to an 8-week course of computerized CBT among opioid- and cocaine-dependent individuals. Galantamine has some preliminary evidence of improving cognitive function and substance use outcomes [48, 49], and is hypothesized to facilitate learning of cognitive skills through CBT, which would, in turn, improve abstinence.

In terms of dissemination, considerable resources are needed to adequately train clinicians in CBT, as well as provide the ongoing supervision needed to achieve/maintain a sufficient level of fidelity to the intervention—resources that are beyond the scope of most community substance abuse clinics that are faced with heavy client caseloads and high clinical staff turnover [50]. One strategy to address these challenges is through technology-delivered CBT, which offers the potential to deliver the main components of an empirically-supported treatment directly to the consumer, while allowing the clinician flexibility to address the various other case management issues that substance users often present with at treatment. Our research group developed "computer-based training for cognitive–behavioral therapy" (CBT4CBT) [51], which uses a multimedia format for delivery of the CBT concepts and coping skills based on the National Institute on Drug Abuse CBT manual [52]. CBT4CBT has demonstrated effectiveness at reducing substance use rates when delivered in combination with standard substance use treatment, with effects persisting through a 6-month follow-up period [53]. Most recently, these effects were replicated in a sample of methadone-maintained opioid-dependent individuals who also met criteria for current cocaine dependence [54]. This line of research may substantially improve the transportability of CBT for substance use disorders.

Another recent development has been a greater understanding of *how* CBT achieves its effect on reducing substance use rates. Although coping skills have long been considered one of the main ingredients (i.e., putative mechanisms) of CBT, statistical demonstration to support the acquisition of coping skills as a mediator of the effect of CBT has been elusive [55]. In one of our trials examining CBT4CBT, we found the quality of individuals' coping skills acquired (rather than the sheer number) mediated the effect of CBT on reducing drug use [56•]. This finding is not only significant for being the first to statistically demonstrate acquisition of coping skills as a mediator of CBT, but also because of the novel aspect of evaluating coping skills, as well as the fact that this finding was generated from a computerized version of CBT, which eliminated the therapist variability. Although future studies need to replicate this finding, it does highlight the potential for computerized interventions to offer more precise investigation of treatment mechanisms.

MI/MET and Other Brief Interventions

Several meta-analyses of motivational interviewing (MI) [57] (and the manualized version known as MET [58]) have indicated fairly strong evidence of efficacy at reducing substance use rates, with durable effects lasting several years in some cases [59, 60]. However, a recent Cochrane review, which evaluated 59 randomized controlled trials of MI/MET with more than 13,000 participants, concluded that MI can reduce the extent of substance use compared with no

intervention, yet there were no significant effects compared with treatment as usual [61]. In spite of this finding (which notes the heterogeneity across studies), MI/MET approaches remain an important component of behavioral treatments for substance use disorders, and have been frequently combined with other evidenced-based approaches (most commonly CBT, as cited above) in order to address the motivational factors required for changing substance use behaviors.

Although there is more evidence to support motivational and other brief interventions for the treatment of tobacco and alcohol use, there is a growing body of literature supporting its use for the treatment of illicit drugs as well. MI has also been found to be particularly effective for younger populations of substance users, including college students [62] and adolescents [63] As with many other evidenced-based approaches that have been adopted and applied across various settings, the mechanisms of MI/MET have yet to be fully understood. Very few studies have analyzed full mediation models [64]. One hypothesized mechanism has been the increase in client "change talk", which is influenced by therapist behaviors and has been found to be a predictor of substance use outcomes [65, 66]. A recent trial designed to test the active ingredients of MI provided some evidence to support change talk as a mediator of MI effects on alcohol reduction, yet only in the early portion of treatment [67•]. This is one of the first studies to experimentally manipulate the hypothesized active ingredients of MI and test their relationship to change mechanisms and treatment outcomes. While limited, it is the strongest support thus far for client change talk as a mechanism of action in MI.

Mindfulness-based Relapse Prevention

One of the most recently developed behavioral treatments for substance use disorders is a type of cognitive–behavioral treatment that incorporates the Buddhist tenets and practices of mindfulness meditation, referred to as mindfulness-based relapse prevention (MBRP) [68, 69]. In MBRP, the mindfulness practices are intended to increase the patient's awareness of external triggers and internal cognitive and affective processes, as well as increase the client's ability to tolerate challenging cognitive, affective, and physical experiences [69, 70]. Rather than use avoidance-based coping strategies, such as thought stopping or reliance on will power, MBRP teaches to observe distressing or uncomfortable emotional or craving states without habitually reacting (comparable to the *urge surfing* skill taught in traditional CBT for substance use disorders). As stress-induced craving has been predictive of relapse [71], MBRP is thought to work, in part, by reducing stress reactions and the subjective experience of craving [70, 72]. Increasing client awareness and acceptance has some preliminary support as a potential mechanism by which MBRP reduces craving [72], yet more research is needed. Although, to date, there have only been a few randomized controlled trials evaluating its effectiveness [73], there is some indication that MBRP reduces craving and reactivity to substance use cues, in turn reducing rates of substance use.

Technology-based Developments

Owing to the rapid growth of technology and the omnipresent use of the internet and mobile devices, many technology-based interventions have been developed as a strategy for overcoming the barriers to implementation described above, increasing access to evidenced-based therapies, and addressing issues that affect substance use treatment outcomes. These interventions come in a variety of delivery formats (e.g., computer-based, mobile phone, tablet, etc.), types of intervention (e.g., brief interventions, behavioral therapy, treatment adherence tools), and have been used across various substances of abuse (e.g., opioid, cocaine, alcohol, cannabis, etc.). Many new technology-based interventions have been based on empirically supported treatments, such as CBT [51], CM [74, 75], community reinforcement approach [76], MET, and other brief interventions [77–79], as well as combinations of these approaches [80, 81]. Recent reviews have indicated preliminary support for these technology-based interventions at reducing substance use rates compared with treatment as usual [82–84], although most have examined these interventions as an adjunct to standard treatment.

Emerging technologies have advanced the use of technology-based interventions beyond acute care treatment and into continuing care models. Technology-based interventions for the continuing care of other chronic conditions, such as cancer, asthma, and HIV/AIDS have also been developed for addictions. For instance, the Center for Health Enhancement Systems Studies at the University of Wisconsin-Madison has developed an intervention that includes a smartphone-based system providing video-counseling, social networking to connect with supports and peers, ecological momentary assessments that lead to tailored interventions like relaxation audio files, avatar-facilitated motivational interviews, and a global positioning system to track locations and intervene when a person has a prolonged stay in a high-risk location. Other emerging technologies that can be incorporated into future interventions include the use of wearable, unobtrusive sensors that may detect the onset of a substance use lapse in real-time or predict relapse before it happens, and provide in-the-moment interventions responsive to the gathered information [84, 85•, 86].

Technology-based interventions offer a number of potential advantages: (1) accessibility and availability across settings; (2) consistent delivery of treatment; (3) freeing up clinician

time; (4) conveying information in an engaging manner; (5) individualization and tailoring of treatment; (6) possible cost-effectiveness [87–90]. One of the most promising features of technology-based interventions for substance use disorders is the potential to provide evidence-based treatments to a broader range of individuals, as nearly 90 % of individuals needing treatment for an illicit drug or alcohol problem do not access treatment [91]. However, the great excitement and promise of technology-based interventions should also be met with some sense of caution regarding the current state of the evidence. Our recent methodological review of randomized trials evaluating computer-assisted therapies found a strikingly small number of studies that utilized high-quality standards currently used as the basis for evaluating behavioral or pharmacological treatments [92••]. Of note, several weaknesses appeared in the literature, including the use of fairly weak control conditions (e.g., wait list control), poor rates of follow-up, and a general lack of attention to issues of internal validity. The early stage of this line of research is somewhat reminiscent of the state of behavioral therapy research 20 years ago, before methodological standards for evaluating clinical trials and the evidence base were instituted [93].

Neuroscience-based Developments

Some of the more exciting developments over the last few years have been based on the contributions of cognitive neuroscience to our understanding of addiction, and the development of new interventions and treatment approaches. Most behavioral therapies for substance use disorders are hypothesized to work through changes in cognitive, affective, and learning processes, yet our understanding of these hypothesized mechanisms have been limited by the methods of the traditional randomized controlled trial approach [94]. However, the recent use of cognitive neuroscience methods to examine these cognitive and affective processes in addictions has the potential to inform existing, and develop new, behavioral treatments for substance use disorders [95••]. Furthermore, neuroimaging methods such as functional magnetic resonance imaging have been used to examine both predictors of drug relapse and changes in the underlying neural circuitry following treatment—valuable information that can be used to design more effective behavioral treatments.

Based on neurocognitive theories that propose addiction is maintained by hyperactivity of an impulsive, automatic processing system, as well as deficits in a higher-order reflective processing system [96, 97], several new interventions have been developed that are designed to target these cognitive systems. One area that has gained particular attention recently is the work on implicit cognitive processes in substance users [98], such as attentional biases for substance-related stimuli, and automatic action tendencies to approach substances [99–101]. For instance, Wiers et al. [102] initially developed an assessment task for measuring the automatically triggered tendency to approach alcohol called the Alcohol-Approach/Avoidance Task, whereby participants push or pull a joystick when presented with various pictures (e.g., alcohol-related, general positive, general negative), essentially mimicking an approach or avoidance movement. This task was subsequently adapted as a training tool, such that participants were specifically instructed to respond to pictures of alcohol by making an avoidance movement (pushing the joystick) and an approach movement (pulling the joystick) to non-alcohol pictures. This automatic approach bias retraining has demonstrated reductions in drinking behavior among hazardous drinkers [103••], and even lower rates of relapse in clinical samples when combined with CBT [104, 105]. Although much of this work has been focused on alcohol, these processes are considered universal across all substances of abuse, as well as other addictive behaviors (e.g., gambling), and such retraining interventions may become important adjuncts to traditional treatments that aim to improve higher order cognitive control.

An example of cognitive training targeting deficits in the higher-order reflective processing system is the research on training working memory. From a neurocognitive perspective, when levels of executive functions (i.e., higher-order reflective processes), such as working memory, are low, substance use behavior is guided more strongly by impulsive, automatic processes [45]. Thus, strengthening working memory and other executive functions would assist individuals in gaining greater cognitive control to avoid impulsive substance use behaviors. There is strong evidence that working memory can be improved through extensive training procedures, and evidence that this training can reduce clinical symptoms in a range of populations [106]. Among substance users, Houben et al. [45] recently reported that training in working memory among problem drinkers improved working memory and reduced alcohol use for more than 1 month after training. Importantly, they found training had an effect on alcohol use for those with strong automatic preferences for alcohol, indicating working memory training may increase control over the underlying automatic processes that drive alcohol use. Working memory training has also demonstrated effects in improving delay discounting amongst stimulant users, suggesting that such training may lead to a greater ability to attend to future consequences and thus reduce impulsive decision making [46•].

Although this line of research, developing neuroscience-based interventions from neurocognitive theories of addiction, is still an emerging area, the results appear promising for improving treatments for substance use disorders. Also, the more traditional computerized cognitive remediation interventions that target a range of executive functions have

seen a rebirth in recent years, as the technology and training content has advanced since its early years as an adjunct treatment for substance use disorders. As our understanding of the interaction between implicit learning mechanisms and higher-order cognitive processes has become more sophisticated, so too have the types of interventions designed to target these processes. Continued work in this area is needed to determine the exact intensity and duration of training, the brain's responses to training, the factors that influence response to training, and to explore the combination of training with pharmacologic cognitive-enhancing agents [107••].

Conclusion

In conclusion, behavioral treatments for substance use disorders are at an important crossroad. No longer is there a question about the existence of effective behavioral treatments, as randomized controlled trials over the last two decades have demonstrated numerous effective treatments, some with effect sizes on par with pharmacologic treatments [4]. However, the question has now become "How do these treatments work, for whom, and under what conditions?" The answers to these questions are still unclear, and the standard method of evaluation through randomized controlled trials has not led to significant advances in effectiveness [94]. In order to achieve successful dissemination and implementation of evidenced-based behavioral treatments into clinical practice, we need a greater understanding of how the treatments work, and how best to maximize the effects so they can be applicable to the broader population.

The integration of technology-delivered formats of treatments for substance abuse has served as a promising solution to the dissemination challenges encountered in the last decade. Several evidenced-based treatments have been re-packaged into client-friendly, convenient, engaging, and easily transferrable multimedia systems with some potentially exciting results. Although most have been found effective at improving treatment outcomes when delivered as a supplement to standard substance abuse treatment (e.g., [51] and [76]), there is some evidence that these technology-based interventions may produce positive outcomes comparable to those observed from clinician-delivered evidenced-based treatment (e.g., [80] and [81]). Yet, the evidence that such interventions may be comparable to standard-format treatments does not indicate a solution to the problems of dissemination. The main questions still remain: "How do they work?", "For whom?", and "Under what conditions?"

One could argue that rather than technology-delivered treatments being the current solution to dissemination in the future systems of healthcare, they could actually be part of the solution to help us answer the above questions. Yes, for the clinical community, technology-delivered interventions offer broader access to evidenced-based treatments. But for the research community, technology-delivered interventions offer a standardized delivery of treatment, with greater control over the dose of treatment provided, as well as the potential for the various components (i.e., putative mechanisms) of the intervention to be easily isolated, manipulated, and examined in a systematic manner (similar to the ability to manipulate the chemical ingredients of a promising pharmaceutical agent to determine the most effective compound). Such scientific evaluation of the components of therapist-delivered interventions have been either methodologically limited owing to the inherent therapist variability, or impractical given the resources needed for these levels of examination. It may not be surprising that one of the first demonstrations of statistical mediation supporting coping skills as a mediator of CBT was generated from a trial of a computer-delivered CBT [56•]. Therefore, the current scientific environment is ripe for greater evaluation of these technology-based interventions to unlock the mysteries of how our evidenced-based behavioral treatments work. However, it is important that such careful evaluation be undertaken prior to dissemination [92••], or many technology-based interventions may suffer the same fate as some promising behavioral treatments 20 years ago.

Finally, expanding our understanding of addiction beyond traditional behavioral, social cognitive, or motivational theories by incorporating neurocognitive theories may advance the field toward more comprehensive answers to the questions above. Recent discoveries in neurobiology and cognitive neuroscience have led to novel approaches for testing and intervening on the underlying neural mechanisms of addiction [95••]. For instance, the identification and assessment of specific automatic cognitive processes, such as automatic approach bias, led to the development of a relatively simple, yet innovative intervention for retraining this neurocognitive mechanism, which has produced positive results in the alcohol field [103••, 104]. Neurocognitive theories could lead to the development of new behavioral treatments that target automatic impulsive processes (i.e., bottom-up processes), which may ultimately serve to improve outcomes of traditional behavioral treatments that target cognitive and affective control (i.e., top-down processes). Thus, the future of behavioral treatments should include more frequent interplays between the tried and true evidenced-based treatments of the last 20 years, with the novel technology-based and neuroscience-based treatments of tomorrow.

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Compliance with Ethics Guidelines

Conflict of Interest Brian D. Kiluk declares that he has no conflict of interest. Kathleen M. Carroll is a member of CBT4CBT LLC, which makes CBT4CBT available to qualified clinical providers and organizations on a commercial basis. Dr. Carroll works with Yale University to manage any potential conflicts of interest.

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