

SPECIAL ISSUE ON ADDICTIONS

# Computerized Cognitive Behavioral Therapy for Substance Use Disorders: A Summary of the Evidence and Potential Mechanisms of Behavior Change



Brian D. Kiluk<sup>1</sup>

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# Abstract

Cognitive-behavioral therapy (CBT) is one of the most evaluated behavioral interventions for substance use disorders, with considerable empirical evidence supporting its efficacy. However, despite CBT's strong support from efficacy trials, broad dissemination and implementation have been challenging. Furthermore, there remains limited understanding regarding CBT's mechanisms of behavior change; the theory-driven assumption that individuals acquire new skills for coping with triggers for substance use has notoriously lacked statistical support. The emergence of computer-delivered interventions has the potential to address dissemination and implementation challenges, as well as offer advantages toward understanding treatment mechanisms. This article will provide a summary of the current evidence supporting one particular computerized CBT program, CBT4CBT. Multiple clinical trials in different treatment settings have indicated CBT4CBT's efficacy at reducing rates of alcohol and drug use when provided as an add-on to standard addiction treatment, as well as when provided with minimal clinical monitoring (i.e., virtual stand-alone). These effects have also been relatively durable after treatment termination, consistent with findings of traditional CBT. It is important to note that the evaluation of individuals' cognitive and behavioral coping skills prior and following treatment has indicated the acquisition/improvement of these skills may be a mechanism of behavior change for those who engage with CBT4CBT. Thus, computerized delivery may be a strategy for enhancing individuals' learning of cognitive and behavioral skills for successfully avoiding substance use. Future work should aim to identify the optimal type of setting, clinician role, and patient characteristics for targeted dissemination and implementation.

Keywords cognitive-behavioral therapy  $\cdot$  substance-use disorders  $\cdot$  CBT4CBT  $\cdot$  mechanisms of behavior change

Brian D. Kiluk brian.kiluk@yale.edu

<sup>&</sup>lt;sup>1</sup> Yale School of Medicine, 40 Temple Street, Suite 6C, New Haven, CT 06510, USA

## Introduction

Cognitive-behavioral therapy (CBT) is one of the most studied behavioral interventions for treating substance use disorders (SUD), and is widely acknowledged as an evidence-based treatment (U.S. Department of Health & Human Services, 2016). Multiple meta-analyses have concluded CBT is an effective treatment for alcohol and drug use, with effect sizes comparable to those of interventions for other psychiatric disorders (Carroll & Onken, 2005; Dutra et al., 2008; Irvin, Bowers, Dunn, & Wong, 1999; Magill & Ray, 2009). It has been shown to be highly compatible with other empirically supported treatments for SUD, such as motivational interviewing and contingency management, and is commonly used as a behavioral therapy platform for pharmacotherapy trials (Carroll & Kiluk, 2017; Carroll, Rounsaville, & Kosten, 2004). However, despite CBT's strong support from efficacy trials, broad dissemination and implementation in the clinical community has proven challenging. Most private and publicly funded addiction treatment centers fail to provide the level of training, monitoring, and ongoing supervision of clinicians' implementation of CBT in order to ensure the level of fidelity and skill in treatment delivery that is required in the clinical trials generating the evidence of efficacy (McLellan, Carise, & Kleber, 2003; Olmstead, Abraham, Martino, & Roman, 2012; Rakovshik & McManus, 2010; Sholomskas et al., 2005). This results in a version of CBT delivered in clinical practice that bears little resemblance to the closely monitored versions in clinical trials, ultimately limiting the effectiveness for the broad population of individuals seeking treatment (Carroll & Kiluk, 2017).

In addition, to better translate CBT's effects from research to practice, there is a need to identify the mechanisms by which individuals reduce or abstain from alcohol/drugs (i.e., mechanisms of behavior change) and the active ingredients of the treatment responsible for that change (Kazdin, 2011; Longabaugh, Magill, Morgenstern, & Huebner, 2013). CBT for SUD is based on social learning theory and the underlying principle that alcohol/drug use is a learned behavior (Abrams & Niaura, 1987; Carroll, 1998; Kadden et al., 1992). Guided by the learning principles of modeling, operant, and classical conditioning, individuals with substance use disorders develop a pattern of alcohol/drug use that produces deficiencies in affective, behavioral, and cognitive coping skills to deal with distressing and negative emotions. As such, one of the primary elements of CBT for SUD is cognitive and behavioral skills training to help individuals exert greater control over learned behavioral patterns, reduce impulsive responding to seek immediate reward in response to alcohol/drug cues via control of craving strategies, improve decision-making and problem-solving skills, and recognize, challenge, and exert control over cognitions associated with alcohol/drug use (Sofuoglu, DeVito, Waters, & Carroll, 2013). However, despite the emphasis on coping skills training in CBT, the evidence supporting improvement in coping skills as a mechanism of CBT for SUD has been mixed (Litt, Kadden, Cooney, & Kabela, 2003; Longabaugh et al., 2005; Longabaugh & Morgenstern, 1999; Magill, Kiluk, McCrady, Tonigan, & Longabaugh, 2015; Roos, Maisto, & Witkiewitz, 2017).

A primary reason for the mixed evidence regarding mechanism may relate to the manner in which traditional CBT is delivered—through a clinician. Variability in fidelity to the intervention, dose and quality of delivery, as well as clinician/therapist factors may directly affect the active treatment ingredients hypothesized to be

responsible for contributing to behavior change (Carroll et al., 2000b; Miller & Rollnick, 2014; Perepletchikova, Treat, & Kazdin, 2007). Clinicians delivering standardized treatment in clinical trials regularly show substantial differences in the outcomes of clients they treat; multilevel models applied to clinical trial data have shown that 5–10% of the total variability in outcomes is attributable to between-therapists differences (Crits-Christoph et al., 1991; Elkin, Falconnier, Martinovich, & Mahoney, 2006; Kim, Wampold, & Bolt, 2006). Furthermore, specific effects are deemed inseparable from "relational" effects (e.g., therapeutic alliance) when treatments are delivered in the context of an interpersonal relationship (Miller & Moyers, 2014), thereby making it difficult to identify CBT's precise mechanisms.

## **Benefits of Computer-Delivered Interventions**

The emergence of computer-delivered interventions offers tremendous promise with respect to making evidence-based treatments more broadly accessible to those who may benefit from them (Carroll & Rounsaville, 2010; Greist, 2008; Marsch, Carroll, & Kiluk, 2014). Computer-delivered interventions have the potential to reach rural populations and other groups whose access to treatment is limited, as well as those who do not seek treatment because of discrimination or stigma (Marks & Cavanagh, 2009; Postel, de Jong, & de Haan, 2005). Furthermore, they also offer significant advantages of standardization and consistent quality, reduction of cost and clinician time, and potential 24/7 availability (Budman, 2000; Cuijpers, van Straten, & Andersson, 2008; Cunningham, 2008; Gibbons et al., 2009; Olmstead, Ostrow, & Carroll, 2010; Wright et al., 2005). In addition, computer-delivered interventions may also facilitate evaluation of mechanisms via delivery of active treatment ingredients in a more focused and concentrated form than is possible with clinician-delivered treatments. One of the key benefits of computerized delivery of interventions is standardization relative to traditional clinician-delivered treatments with respect to variability in treatment fidelity, quality, and delivery of active and common elements (Carroll & Rounsaville, 2010; Marks & Cavanagh, 2009; Marsch & Dallery, 2012). These characteristics make computer-delivered interventions a promising solution to the dissemination and implementation challenges, as well as the challenges in identifying mechanisms, that have limited CBT's broad use in clinical practice.

## Computer-Based Training for Cognitive-Behavioral Therapy

With a desire to implement CBT more consistently, with a high level of quality, and at lower cost, our research group at Yale University developed a computer-based training version of CBT for substance use disorders, called CBT4CBT (Carroll et al., 2008). The CBT4CBT program consists of seven modules (i.e., core skills) targeting substance-use disorders, the content of which is based closely on the CBT manual published by the National Institute on Drug Abuse (Carroll, 1998). In developing CBT4CBT, the aim was to construct a highly engaging version of CBT that could take advantage of the capacity of computer-based learning to convey key CBT skills via a range of media (e.g., video, graphics, audio instruction, interactive exercises). Video-

based examples were incorporated to emphasize learning of targeted behavioral, cognitive, and affective strategies, with emphasis on modeling from examples of individuals utilizing skills in a range of realistic situations. CBT4CBT was conceived as a "skills training machine"; one that seeks to teach a core set of generalizable CBT strategies (functional analysis, coping with craving and strong affect, problem solving, decision making, challenging thoughts, and assertive drug refusal). Interactive exercises are included to reinforce patients' understanding of targeted skills, as well as practice assignments (i.e., homework) to encourage implementation and practice of skills, and thus enhance durability of treatment effects.

#### Efficacy as an Adjunct to Standard Treatment

Two independent 8-week trials of CBT4CBT for substance-use disorders have evaluated the efficacy of the program as an adjunct to standard outpatient treatment (Carroll et al., 2008; Carroll et al., 2014). In each trial, participants assigned to CBT4CBT were provided with access to the computerized program at the clinic site, typically engaging with the program on the same day they presented for their standard outpatient treatment. The initial trial included 77 individuals entering outpatient addiction treatment randomized to either standard treatment as usual (TAU, weekly individual and/or group counseling) or standard TAU with access to CBT4CBT for 8 weeks. Nearly 80% of participants were users of both alcohol and drugs in this trial. In terms of outcome, those assigned to the CBT4CBT condition submitted a significantly lower proportion of urines that were positive for any drugs compared to TAU (34% vs. 53%, respectively), and a longer duration of continuous abstinence compared to TAU (22 vs. 15 days), with both differences representing a moderate effect size (Carroll et al., 2008).

The second trial replicated and extended these findings in a sample of 101 cocainedependent methadone-maintained individuals, a more homogeneous but highly challenging clinical population (Carroll et al., 2014). In this trial, TAU consisted of daily methadone maintenance and weekly group sessions. Again, those assigned to CBT4CBT were also provided access to the computerized program on a dedicated computer in a private room within the clinic. Results indicated those assigned to CBT4CBT plus TAU submitted more drug-free urine specimens, and were more likely to attain 3 or more weeks of continuous abstinence from cocaine, than TAU alone (Carroll et al., 2014). Random effect regression analyses of drug use across time indicated a significant enduring benefit of CBT4CBT in both trials, such that those assigned to CBT4CBT plus TAU tended to decrease their substance use over the 6month follow-up period compared to TAU alone (Carroll et al., 2009; Carroll et al., 2014). Thus, one of the distinguishing features of traditional CBT, its relative durability of effects (i.e., "sleeper effect"; Carroll et al., 2000a, b; Carroll et al., 1994; Rawson et al., 2002), appears to be retained in its translation to computer-assisted format.

#### Adapted for Other Populations

In addition to a version for general substance use disorders, our team at Yale University has also developed a version adapted specifically to target alcohol use (Kiluk et al., 2016). The CBT4CBT for alcohol-use disorders (AUD) program retained the structure, features, and basic core CBT skills of the original version, but with additional alcohol-

specific content and skill-based examples drawn from the CBT manual published by the National Institute on Alcohol Abuse and Alcoholism (Kadden et al., 1992). Results from an initial pilot study conducted at an outpatient addiction treatment facility indicated those assigned to CBT4CBT for AUD plus TAU had a greater increase in their rate of alcohol abstinence, and greater decrease in heavy drinking days during the 8-week treatment period than those assigned to TAU only (Kiluk et al., 2016). We also found those assigned to CBT4CBT plus TAU attended more treatment sessions and were more likely to complete the treatment protocol compared to TAU.

A culturally adapted version of CBT4CBT for Spanish-speaking populations with SUD has also been developed, which integrated Latino/a cultural values into to content of the program. This is a population that experiences significant health disparities, with elevated rates of substance use and related problems, yet limited access to behavioral health treatments (Alegria, Alvarez, & Falgas-Bague, 2017; Guerrero, Marsh, Khachikian, Amaro, & Vega, 2013). Results from a randomized trial with 92 primary Spanish-speaking adults with current substance-use disorder conducted at outpatient facilities providing substance-use and mental-health services to Spanish-speaking clients, indicated those assigned to CBT4CBT-Spanish plus TAU demonstrated a greater reduction in the frequency of substance use during the 8-week trial compared to TAU only, with effects maintained through a 6-month follow-up (Paris et al., 2018).

#### Efficacy as a Virtual Stand-Alone Treatment

Two independent randomized trials that evaluated CBT4CBT as a potential "standalone" treatment for SUD have been conducted. In each of these trials, participants assigned to the stand-alone CBT4CBT condition were provided with access to the CBT4CBT program at the clinic site and asked to complete one module per week as their principal form of treatment, in conjunction with brief (10-minute) weekly clinical monitoring provided in-person by a doctoral-level clinician. The clinical monitoring sessions were intended as a means of evaluating clients' functional status and safety, address clients' questions or concerns, and support their engagement with the CBT4CBT program. This treatment condition was first incorporated in the trial described above evaluating CBT4CBT for AUD, which included a TAU condition, as well as a CBT4CBT plus TAU condition (Kiluk et al., 2016). Results from that 8-week trial indicated rates of alcohol abstinence decreased across all treatment conditions, with no significant difference in alcohol abstinence between those assigned to CBT4CBT plus monitoring (i.e., "stand-alone") compared to TAU only. In addition, those assigned to CBT4CBT plus monitoring had greater rates of treatment retention and incurred fewer costs associated with AUD treatment compared to TAU only (Kiluk et al., 2016).

The most recently completed trial that included CBT4CBT as a stand-alone treatment was conducted with 137 substance-dependent individuals seeking treatment at an outpatient addiction treatment facility (Kiluk et al., 2018). Treatment conditions in this 12-week trial included standard TAU, CBT4CBT plus monitoring, as well as a therapist-delivered CBT condition. This was one of the first trials to include both a computerized and therapist-delivered version of CBT in a clinical sample. Results indicated those assigned either CBT4CBT plus monitoring or therapist-delivered CBT demonstrated a greater reduction in

the frequency of substance use than those assigned to TAU only during the 12week treatment period. Although the study was not powered as a direct test of computer-delivered versus therapist-delivered CBT, those assigned to CBT4CBT consistently achieved the best outcomes in terms of treatment retention, engagement, and substance use (Kiluk et al., 2018).

# Mechanisms of Computerized CBT

# **Acquisition of Coping Skills**

All completed trials of CBT4CBT have included repeated assessment of putative mechanisms, with an emphasis on the acquisition of coping skills, consistent with CBT theory. The primary assessment for measuring coping skills in these trials has been an audio-taped role-play adapted from the Situational Competency Test (Chaney, O'Leary, & Marlatt, 1978), called the Drug Risk Response Test (DRRT; Carroll, Nich, Frankforter, & Bisighini, 1999; Kiluk, Nich, Babuscio, & Carroll, 2010). In this task, individuals are presented with a series of hypothetical situations that are deemed high risk for drug and/or alcohol use. They are instructed to image themselves in each situation and verbally state how they would respond as if the situation were occurring at that moment. The responses are recorded and later scored by independent evaluators using a Likert-based scoring system to rate the individuals' response along a number of variables, including the quality of the coping skill (rated from 1 to 7: "poor response, would definitely use drugs or alcohol" to "excellent response, no chance of using drugs or alcohol"). Results from the initial trial of CBT4CBT (Carroll et al., 2008) indicated those assigned to CBT4CBT plus TAU showed a greater increase in the quality of their coping skills during the course of treatment, with continued increase during the 6-month follow-up period, compared to TAU only (Kiluk et al., 2010). It is important to note that improvement in the quality of skills was a statistical mediator of posttreatment drug use, which was the first successful demonstration that the acquisition of coping skills was a mediator of substance-use outcomes of CBT (Kiluk et al., 2010; Longabaugh, 2010). Although this mediation finding was not fully replicated in the second CBT4CBT trial that included methadone-maintained cocaine-dependent individuals (Carroll et al., 2014), those in the trial with lower quality skills at baseline did show greater improvement when assigned to CBT4CBT (Kiluk et al., 2017). In the CBT4CBT for AUD trial (Kiluk et al., 2016), individuals in all three treatment conditions (TAU, CBT4CBT plus TAU, CBT4CBT plus monitoring) improved the quality of their coping skills during the course of the 8-week treatment, without differential change according to treatment assignment. However, the quality of coping skills rated at the end of treatment were correlated with alcohol abstinence for those assigned to one of the CBT4CBT conditions (CBT4CBT plus TAU: r = .51, p < .05; CBT4CBT plus monitoring: r = .44, p = .05), but not for those assigned to TAU (r = .07, p = ns; unpublished data). This suggests that the quality of skills acquired from CBT4CBT may be an important contributor toward alcohol abstinence.

## Knowledge of CBT Concepts

Teaching of concepts and skills plays a prominent role in CBT interventions for SUD. Therapists introduce and review new concepts and strategies for successfully avoiding substance use, which includes how to understand behavioral patterns (i.e., functional analysis), recognize triggers and cope with cravings, challenge automatic/negative thoughts, refuse offers of drugs/alcohol, and develop strategies for decision making and problem solving. Although questionnaires have been used to assess CBT knowledge gained by therapists following workshop or other training methods (Scott, Klech, Lewis, & Simons, 2016; Sholomskas et al., 2005; Weingardt, Cucciare, Bellotti, & Lai, 2009), there has been little evaluation of knowledge gained by patients during a course of CBT treatment. This is surprising, given the expectation that patients are *learning* new skills in CBT. To examine the potential contribution of learning CBT concepts toward behavior change, two of the most recent CBT4CBT trials have included a 40item true/false test to assess basic knowledge of cognitive and behavioral concepts (e.g., "everyone's triggers are the same," "you cannot change the way your brain thinks about things") at baseline and end-of-treatment. In the CBT4CBT for AUD trial (Kiluk et al., 2016), those assigned to one of the CBT4CBT conditions showed a greater increase in scores on the true/false test compared to TAU [F(2,36.15) = 3.83, p < .05] (unpublished data). Percent correct scores for those assigned to CBT4CBT plus TAU improved from 71% correct at baseline to 83% correct at end of treatment; scores for those assigned to CBT4CBT plus monitoring improved from 78% to 83% correct; scores for those assigned to TAU were relatively unchanged from 77% correct to 76% correct.

From the CBT4CBT trial that included both a therapist and computer-delivered CBT, participants as a whole increased their scores from baseline to end-of-treatment [F(1,49) = 8.04, p < .01), with the largest gain for those assigned to CBT4CBT plus monitoring (from 74% to 81% correct; Kiluk et al., 2018). It is interesting that scores for those assigned to therapist-delivered CBT remained relatively unchanged over time, from 64% to 66% correct. Although the sample size for those assigned to therapist-CBT who completed both the baseline and end-of-treatment true/false quiz was comparatively small (n = 11), these results suggest the potential benefits of teaching cognitive and behavioral concepts through a computer-delivered program. An additional evaluation of this true/false quiz, particularly with respect to association with outcomes is ongoing.

#### Therapeutic Alliance

The quality of the therapeutic relationship (i.e., "therapeutic/working alliance") is considered an important factor contributing to patient engagement and outcomes in traditional psychotherapies, such as CBT (Horvath, Del Re, Flückiger, & Symonds, 2011; Lambert & Barley, 2001; Martin, Garske, & Davis, 2000). However, relatively little is known about whether the concept of an alliance is relevant when an intervention is delivered through a computer rather than through a therapist, and whether it influences outcome in a manner similar to a patient–therapist alliance. To examine whether patients might form an alliance with the CBT4CBT program and explore its impact on treatment engagement and outcomes, an adapted version of a widely used

instrument for measuring the patient-therapist alliance, the Working Alliance Inventory (WAI; Horvath & Greenberg, 1989), was developed to measure the patient-program alliance and included in a CBT4CBT trial with methadone-maintained cocaine-dependent individuals (Carroll et al., 2014). This adapted version, the Working Alliance Inventory for Technology-Based Interventions (WAI-Tech; Kiluk, Serafini, Frankforter, Nich, & Carroll, 2014), instructed participants in the trial to rate their level of alliance with the CBT4CBT program only, not the computer itself or the research team, along the same three dimensions as the WAI-task, bond, and goal. For example, items on the WAI-Tech read, "My interactions with the CBT4CBT program are important to me"; "I agree with the CBT4CBT program about the things I will need to do to help improve my situation"; and "It seems as if the CBT4CBT program and I understand each other." Response options are on a 7-point Likert-type scale from 1 ("never") to 7 ("always"). The same items on the standard WAI read, "My interactions with my therapist are important to me"; "I agree with my therapist about the things I will need to do to help improve my situation"; and "It seems as if my therapist and I understand each other." Because CBT4CBT in this trial was provided as an add-on to TAU, all participants also rated the level of alliance with their substance-abuse counselor (i.e., therapist) at the treatment facility using the standard WAI.

Overall, participants rated a relatively strong alliance with the CBT4CBT program (mean WAI-Tech score for Total scale = 5.5 out of 7 possible), with scores remaining stable over time and not significantly different than scores on the WAI measuring alliance with their therapist (Kiluk et al., 2014). It is interesting that results of correlations between scores on the WAI-Tech and treatment outcomes, such as the percentage of days cocaine abstinent, and percentage of cocaine-negative urine samples, revealed few significant correlations, whereas scores on the WAI for those not assigned to CBT4CBT were significantly correlated with treatment outcomes. Thus, although the level of the patient-program alliance was similar in strength to the patient-therapist alliance, the patient-program alliance did not have the same impact on outcomes as the patient-therapist alliance. This suggests that computer-based delivery of CBT seemingly removes the contribution of the therapeutic alliance, which may enhance the ability to detect the active treatment ingredients of CBT that contribute to behavior change. More work in this area is needed, because these results appeared in a trial wherein CBT4CBT was provided as an add-on to TAU. Evaluation of the WAI-Tech in more recent trials that included a stand-alone CBT4CBT condition is ongoing.

## Summary and Discussion

Results from multiple well-controlled RCTs indicate CBT4CBT is efficacious at reducing rates of substance use when provided as an add-on to standard outpatient addiction treatment (Carroll et al., 2008; Carroll et al., 2014; Kiluk et al., 2016; Paris et al., 2018), as well as when provided as a virtual "stand-alone" with minimal clinical monitoring (Kiluk et al., 2016; Kiluk et al., 2018). Furthermore, evaluation of its mechanisms has revealed that individuals appear to increase the quality of their coping skills acquired during treatment, and this in part contributes to their abstinence from drugs and alcohol. There is also some indication that individuals gain greater knowledge of cognitive and behavioral concepts from CBT4CBT than from standard

addiction treatment, or even therapist-delivered CBT, which may play a role in its efficacy. Lastly, it appears individuals do form a therapeutic relationship with the CBT4CBT program that is comparable to the relationship formed with a therapist, however this relationship may not have the same function in treatment as in traditional psychotherapy, which could have benefits toward identifying unique mechanisms of behavior change from CBT.

Overall, these results, and those from other computer-based CBT interventions for substance-use disorders (e.g., Budney et al., 2015; Campbell et al., 2014; Kay-Lambkin, Baker, Lewin, & Carr, 2009), hold great promise for addressing the dissemination and implementation challenges of delivering CBT in clinical practice. From a public health perspective, these programs can broaden access to an evidence-based treatment for the population of individuals with substance-use problems who do not receive care due to limited availability, costs, stigma, concerns about confidentiality, or other reasons (Carroll & Kiluk, 2017). From a scientific perspective, these interventions offer the opportunity to better identify and isolate the essential treatment components that contribute to behavior change, thereby advancing the development of highly concentrated interventions that might one day be tailored according to patient profiles. However, there are several questions regarding the target population and implementation options, as well as barriers such as clinician attitudes and the rapidly changing technological landscape, that may complicate the realization of these benefits in the future.

Despite the promise of CBT4CBT, there is still limited understanding regarding how exactly it works and for whom it might work best. Just as with other evidence-based interventions for substance-use disorders (and other psychiatric conditions), not all patients respond to CBT4CBT, such as by demonstrating reductions in frequency/ quantity of substance use or achieving sustained abstinence. Prior work to identify patient-level characteristics associated with greater or lesser benefits of CBT4CBT has included characteristics of cognitive functioning, such as general intelligence (Kiluk, Nich, & Carroll, 2011a) and risk-taking (Carroll et al., 2011), emotional characteristics, such as alexithymia (Morie, Nich, Hunkele, Potenza, & Carroll, 2015), as well as genetic characteristics (Carroll et al., 2015). The identification of robust predictors of treatment response (or nonresponse) that might inform guidelines for applications of CBT4CBT is ongoing. Current efforts seek to address how the components of the intervention might change, or be impacted by, various patient characteristics, including the core features of addiction, such as executive functioning, negative emotionality, and incentive salience, outlined by the Addictions Neuroclinical Assessment (Kwako, Momenan, Litten, Koob, & Goldman, 2016). Answers to these questions may be crucial for developing a more effective and precise behavioral intervention and will likely have implications for broad dissemination/implementation strategies as well. For instance, such information could inform decisions regarding whether CBT4CBT (or which components) would be an appropriate treatment option for an individual with a given profile of demographic and clinical characteristics, as well as the setting and types of adjunctive treatment/ interventions necessary to achieve and maintain positive outcomes.

There are also several barriers that may influence the potential impact of computerized or technology-based interventions, such as CBT4CBT. One is the limited uptake of self-guided interventions provided through the web or mobile applications, in which low participation and high rates of attrition are common (Christensen, Griffiths, & Farrer, 2009; Kelders, Kok, Ossebaard, & Van Gemert-Pijnen, 2012; Kiluk et al., 2011b; Yeager & Benight, 2018). Merely making an evidence-based computerized intervention widely available for free on the internet does not necessarily translate to successful outcomes for individuals in need. Some contact with a clinician, or delivery within a clinical setting, has been shown to enhance patient engagement and outcomes with computerized CBT (e.g., Andersson, Carlbring, Berger, Almlov, & Cuijpers, 2009; Kenwright, Marks, Graham, Franses, & Mataix-Cols, 2005; Richards & Richardson, 2012). Second, attitudes toward computerized interventions play a role in successful implementation; prior studies have indicated reluctance among both patients and clinicians to engage with or refer to a computerized intervention (Brooks, Ryder, Carise, & Kirby, 2010; Buti et al., 2013; Carper, McHugh, & Barlow, 2013; Perle et al., 2013). Within the conduct of our clinical trials of CBT4CBT, clinicians have expressed fears regarding "being replaced" by a computer. Such attitudes, although misguided, could serve as a barrier toward the implementation of an evidence based computerized intervention.

Finally, the speed with which technology advances far surpasses the pace of empirical evaluation of an intervention, potentially limiting the utility of the technology-based product once efficacy has been demonstrated. To illustrate this point, the original CBT4CBT program developed and evaluated in our two initial randomized trials (Carroll et al., 2008; Carroll et al., 2014) was provided on a DVD/CD-ROM platform, a virtually obsolete technology in today's world. The amount of time required for careful development of an intervention, evaluation of efficacy, and systematic examination of mechanisms and moderators within well-controlled randomized trials shelf-life of the technology-based delivery method. Although the field should not seek to ease the scientific burden by relaxing methodological standards for evaluating these interventions, the development of such interventions would benefit from strong collaborations with experts in technology to consider the latest technolog-ical advances in product development.

In sum, there is great promise for technology-based interventions, such as CBT4CBT, to expand access to cognitive-behavioral therapy and reduce the gap between research and clinical practice in the treatment of substance-use disorders. At the same time, such optimism should be balanced with a sense of caution by ensuring the same scientific rigor and responsibility as when evaluating and disseminating a pharmacological or behavioral therapy, with continued pursuit toward understanding *how* and *for whom* this works best.

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