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Review

Mechanisms of change associated with technology-based interventions for substance use

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ABSTRACT

Background: Technology-based interventions (TBIs) for substance use disorders have been increasing steadily. The mechanisms by which TBIs produce change in substance use outcomes have not been reviewed. This article is the first review of the conceptual and empirical underpinnings of the mechanisms associated with TBIs for substance use disorders.
Methods: We review the literature on potential mechanisms associated with TBIs targeting tobacco, alcohol, and poly-substance use. We did not identify TBIs targeting other drug classes and that assessed mechanisms.
Results: Research suggests that TBIs impact outcomes via similar potential mechanisms as in non-TBIs (e.g., in-person treatment), with the exception of substance use outcomes being associated with changes in the quality of coping skills. The most frequent potential mechanisms detected were self-efficacy for tobacco abstinence and perceived peer drinking for alcohol abstinence.
Conclusions: Research on mechanisms associated with TBIs is still in a nascent stage. We provide several recommendations for future work, including broadening the range of mechanisms assessed and increasing the frequency of assessment to detect temporal relations between mechanisms and outcomes. We also discuss unique challenges and opportunities afforded by technology that can advance theory, method, and clinical practice.

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1. Introduction

One of the most significant advances in the treatment of substance use disorders (SUDs) in the last decade is the use of information and digital technology to deliver evidence-based interventions. Technology-based interventions (TBIs) for SUDs constitute approaches to care delivered via computer, Internet, or mobile devices – either as stand-alone programs or as adjuncts to more traditional, in-person treatment (Marsch and Dallery, 2012; Kiluk and Carroll, 2013; Litvin et al., 2013). The significance stems not only from the potential of technology to increase access to, and cost-effectiveness of, evidence-based treatment, but also from its ability to provide personalized, on-demand access to therapeutic content and support. Research suggests that TBIs can produce outcomes that are comparable to, and potentially more cost-effective than, approaches delivered by trained clinicians (Gustafson et al., 2014; Marsch and Dallery, 2012; Marsch et al., 2014).

As with all interventions, researchers should establish not just *that* the intervention changed substance use, but *how* treatment produced the changes. That is, researchers should identify the mechanisms responsible for changes in substance use. Mechanisms refer to treatment-induced changes in biological, cognitive, behavioral or environmental factors, which are then in turn responsible for drug abstinence. For example, an increase in the quality of coping skills following computerized cognitive-behavioral therapy (CBT) may enable cocaine abstinence (Kiluk et al., 2010), or an increase in access to reinforcers that are incompatible with substance use following a community reinforcement approach may decrease substance use (Hunter et al., 2014). Researchers can use this information about mechanisms to optimize further iterations of an intervention.

Although mechanisms can be assessed for all interventions, technology entails some unique challenges and opportunities that may make such assessment even more useful. First, assessing mechanisms should help ensure that even in light of the rapid pace of technological innovation, the key mechanisms associated with change are still present and targeted. Second, assessing mechanisms will be useful in identifying similarities and differences to more traditionally-delivered psychosocial treatments. Given the opportunity for ubiquitous access to TBIs, the nature, rate, and sustainability of changes in mechanisms may differ relative to those observed from traditional interventions. Finally, the frequent, longitudinal assessment afforded by technology-based monitoring of mechanisms and substance use outcomes may clarify the roles of mechanisms, or reveal new mechanisms in changing behavior.

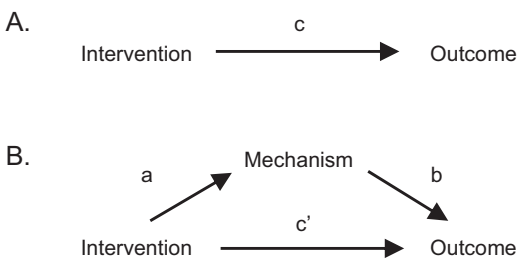

Fig. 1. Graphical representation of an unmediated model (A) and a mediated model (B).

Because most research on TBIs employs randomized controlled trials (RCTs), we consider five statistical criteria to identify potential mechanisms in TBIs (Baron and Kenny, 1986; MacKinnon, 2008). Each criterion should be evaluated with reference to Fig. 1. The top panel shows that some treatment produced change in an outcome, which is known as an unmediated model. The bottom panel shows a mediated model, in which treatment produces change in the outcome by first producing change in the potential mechanism, which for our purposes is synonymous with a statistical mediator. A case for a potential mechanism would be made under the following five conditions: (a) participants in treatment show significantly greater change on the outcome than controls (path c)[3]; (b) participants in treatment show significantly greater change on the mediator than controls (path a); (c) change in the mediator is significantly correlated with change in the outcome in the treatment condition (path b); (d) the effect of treatment on the outcome, after controlling for change in the mediator (path c′), is significantly reduced (for partial mediation) or eliminated (for complete mediation), relative to when the outcome is regressed only on the treatment condition (path c); and (e) change in the mediator occurs before change in the outcome. The first four conditions constitute Baron and Kenny's causal steps, and the fifth condition is known as the temporal precedence criterion (Baron and Kenny, 1986; Kazdin, 2007).

In this article, we perform a narrative review of the literature on potential mechanisms in the context of TBIs for SUDs. Research on mechanisms in the treatment of SUDs is in the formative stage (Morgenstern et al., 2013). Advances are still occurring in conceptual frameworks, research designs, statistical analyses, and measures to assess various mechanisms. In addition, research on TBIs for SUDs is growing at a fast pace (Marsch and Dallery, 2012). As such, a review of mechanisms associated with TBIs is both timely and necessary to serve as a benchmark for future research, and to highlight how technology-based methods may be employed to enhance the assessment of mechanisms. To our knowledge, this is the first review of the conceptual underpinnings and empirical status of mechanisms associated with TBIs for SUDs.

2. Methods

We conducted a literature search in PubMed using search terms associated with information and digital technology (technology, Internet, web, mobile phone, cell phone, smart phone, computer), mechanisms (mediation, mediator, mechanism), and substance use (tobacco, nicotine, smoking, cigarettes, cannabis, marijuana, alcohol, drinking, opiate, opioid, heroin, cocaine, amphetamine, methamphetamine, drug use, addiction). We used all combinations of search terms from each category for articles published up to September, 2014, and we only included articles that statistically evaluated potential mechanisms of psychosocial treatments (i.e., a formal mediation analysis). To maintain a focus on advances in information technology and due to space constraints, we excluded studies that relied solely on more traditional, phone-based counseling. In addition, we restricted our review to potential mechanisms that represented theory-derived mechanisms, and not generic, treatment process mediators such as level of engagement or perceived relevance of the content of the intervention. Our search yielded 482 potential studies. We evaluated the titles and abstracts of each article and selected 66 for full-text review. We searched these articles' references sections and identified an additional 95 relevant articles. Of the 161 articles we identified for review, 37 were not treatment studies (e.g., reviews, commentaries), 78 did not include formal mediation analyses, 12

[3] Some researchers argue that this requirement may not be necessary. It is possible to have mediated effect even if independent variable (*X*) and outcome (*Y*) is not significantly associated. In this case, *X* would affect *Y* though an indirect path (Hayes, 2009; MacKinnon, 2008).