



Cognitive control training for emotion-related impulsivity

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ABSTRACT

Many forms of psychopathology are tied to a heightened tendency to respond impulsively to strong emotions, and this tendency, in turn, is closely tied to problems with cognitive control. The goal of the present study was to test whether a two-week, six-session cognitive control training program is efficacious in reducing emotion-related impulsivity. Participants ($N = 52$) reporting elevated scores on an emotion-related impulsivity measure completed cognitive control training targeting working memory and response inhibition. A subset of participants were randomized to a waitlist control group. Impulsivity, emotion regulation, and performance on near and far-transfer cognitive tasks were assessed at baseline and after completion of training. Emotion-related impulsivity declined significantly from pre-training to post-training and at two-week follow-up; improvements were not observed in the waitlist control group. A decrease in brooding rumination and an increase in reappraisal were also observed. Participants showed significant improvements on trained versions of the working memory and inhibition tasks as well as improvements on an inhibition transfer task. In sum, these preliminary findings show that cognitive training appears to be well-tolerated for people with significant emotion-driven impulsivity. Results provide preliminary support for the efficacy of cognitive training interventions as a way to reduce emotion-related impulsivity.

Impulsive responses to strong emotions are increasingly recognized as a common feature of many diverse forms of psychopathology (Johnson, Carver, & Joormann, 2013). The concept of a distinct emotion-related type of impulsivity began in large part with the publication of the influential UPPS model of impulsivity (Whiteside & Lynam, 2001; Whiteside, Lynam, Miller, & Reynolds, 2005), which differentiated Negative Urgency (the tendency to act impulsively in negative mood states) from other forms of impulsivity. This model has since been extended to include Positive Urgency, or tendencies toward impulsive reactions to positive mood (Cyders et al., 2007). More recently, researchers have suggested that Positive and Negative Urgency may not be truly distinct factors, but instead may be grouped together into a general feature of emotion-related impulsivity (Carver, Johnson, Joormann, Kim, & Nam, 2011).

Various indices of emotion-related impulsivity (ERI) are robustly correlated with a range of symptoms, problematic behaviors, and clinical diagnoses. A recent meta-analysis of more than 40,000 individuals found that compared to other aspects of impulsivity, Urgency was the strongest predictor of every psychopathology or symptom group studied, including anxiety, depression, eating disorders, aggression, borderline personality traits, suicidality and non-suicidal self-injury (Berg, Litzman, Bliwise, & Lilienfeld, 2015). ERI is also elevated in many psychiatric disorders, including bipolar disorder (Muhtadie,

Johnson, Carver, Gotlib, & Ketter, 2014) and major depressive disorder in remission (Carver, Johnson, & Joormann, 2013), and several longitudinal studies show that ERI can predict the onset and course of psychopathologies (e.g., Riley, Combs, Jordan, & Smith, 2015; Smith, Guller, & Zapolski, 2013).

A growing body of theory and research has focused on mechanisms that might contribute to ERI. At a conceptual level, multiple theories state that impulsivity, including ERI, might be best understood within the context of two-mode models (Carver, Johnson, & Joormann, 2008). These models describe how the tendency to react impulsively during strong emotions is shaped by the relationship between a bottom-up, reflexive, system (such as automatically initiating responses without deliberation) and a top-down, reflective system (including cognitive control mechanisms). Consistent with two-mode models, empirical evidence indicates that deficits in top-down cognitive control overlap substantially with many behavioral conceptualizations of impulsivity (Sharma, Markon, & Clark, 2014). Cognitive control circuitry implicated in impulsivity is also involved in emotion regulation: for example, successful use of the emotion regulation strategy of reappraisal is linked to engagement of dorsolateral prefrontal cortex (dlPFC; Buhle et al., 2014), while weakened dlPFC activation is linked to impulsivity (Figner et al., 2010). In sum, converging evidence supports a two-mode view of impulsive behavior.

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Drawing from this two-mode model, Carver and colleagues developed a factor-analytically derived composite measure of impulsivity, which included a factor specific to impulsive speech and behavior in response to emotion—“Feelings Trigger Action” (FTA). The FTA measure includes items from the Negative and Positive Urgency scales, as well as additional items measuring reflexive responses to emotions (Carver et al., 2011). FTA scores have been associated with many dimensions of psychopathology (Johnson et al., 2013) and diagnoses (Carver et al., 2013). Given its broad applicability to outcomes and its inclusion of items from two well-validated impulsivity scales, the FTA measure was used as the primary outcome variable in this study.

1. Impulsivity is related to cognitive control deficits

A growing body of empirical research suggests that different forms of impulsivity can be tied to deficits in cognitive control, including response inhibition (the ability to withhold or cancel a behavioral response; Bari & Robbins, 2013) and working memory (WM; the capacity to briefly store, update, and monitor information; Wesley & Bickel, 2014). Beyond impulsivity, response inhibition and WM deficits are found in many forms of psychopathology (Snyder, Miyake, & Hankin, 2015). Thus, cognitive control deficits in response inhibition and WM are two common factors linking psychopathology and impulsivity.

There is also strong evidence that these same cognitive control deficits are important components of ERI in particular. Both the Negative and Positive Urgency measures have been linked to poor performance on response inhibition tasks in multiple studies (Cyders & Coskunpinar, 2011; Johnson, Tharp, Peckham, Sanchez, & Carver, 2016). In contrast, direct evidence linking ERI to deficits in WM has been mixed. The lack of a clear relationship between these two constructs is surprising, given that WM capacity is thought to be an important component of the ability to use strategies such as reappraisal to regulate emotions (Schmeichel, Volokhov, & Demaree, 2008). Results of one recent study found evidence that weaknesses in WM may indirectly play a role in the expression of ERI, showing that Negative Urgency was related to inhibition deficits only in the context of low WM capacity (Gunn & Finn, 2015). However, WM weaknesses also directly correlated with negative urgency in this study. Taken together, these results indicate a role for both WM and response inhibition as potential mechanisms underlying ERI.

Given the extensive evidence for cognitive control deficits underlying impulsivity, we hypothesized that remediating cognitive deficits would yield changes in ERI. Although researchers have not tested the ability of cognitive training to shift ERI per se, several have considered effects of cognitive training on behaviors relevant to impulse control. Researchers have used modified response inhibition paradigms to train inhibition of disorder-specific cues, with results supporting the efficacy of these interventions in reducing drinking behavior (Houben, Nederkoorn, Wiers, & Jansen, 2011), and high-calorie food consumption (Houben & Jansen, 2011). A smaller number of studies have tested whether training basic inhibitory control, rather than inhibition to specific cues, can help reduce impulsivity-related behaviors. Some evidence supports this hypothesis, with effects of inhibition training on risky decision making on a gambling task (Verbruggen, Adams, & Chambers, 2012), reduced alcohol consumption (Jones et al., 2011), and more efficient emotion regulation at the neural level (Beauchamp, Kahn, & Berkman, 2016). Taken together, these findings suggest the merit of considering general response inhibition training for ERI.

In addition to response inhibition, three lines of work suggest the potential of WM training for reducing ERI. First, at the neural level of analysis, WM plays a role in inhibition itself: a meta-analysis of neuroimaging studies shows that WM resources support successful response inhibition when more complex inhibition tasks are used (Simmonds, Pekar, & Mostofsky, 2008). Similarly, another meta-analysis finds that complex versions of response inhibition tasks recruit many of the same neural regions as WM tasks, including dlPFC (Criaud & Boulinguez,

2013). Second, WM training alone has been found to reduce impulsive choice in adults with stimulant abuse disorders (Bickel, Yi, Landes, Hill, & Baxter, 2011) and to reduce alcohol consumption (Houben, Wiers, & Jansen, 2011). Third, several studies have used WM training to improve emotion regulation in mood disorders. In these studies, cognitive training included an adaptive Paced Auditory Serial Addition Task (PASAT), a computerized auditory WM task. Use of this task has been shown to enhance cognitive control via selective activation of dlPFC (Price, Paul, Schneider, & Siegle, 2013) and to reduce brooding rumination, a maladaptive emotion regulation strategy (Siegle, Ghinassi, & Thase, 2007; Siegle et al., 2014). These studies demonstrate that training basic cognition can enhance control over emotional responses, suggesting that similar training could be helpful for ERI.

In sum, evidence supports a role for response inhibition in influencing ERI, and a role for WM in either supporting inhibition or directly influencing impulsivity and related outcomes. Intriguingly, effects of WM training and inhibition training are relatively domain-specific, with evidence showing that inhibition training does not lead to improvements in WM, and vice versa (Maraver, Bajo, & Gomez-Ariza, 2016). Given these findings, one goal of this study was to conjointly train response inhibition and WM in order to maximize the effects of two hypothetical mechanisms of change.

2. Aims and hypotheses

The goal of this study was to test whether a combined cognitive control training intervention comprising both response inhibition and WM could reduce ERI. We hypothesized that the intervention would reduce ERI and improve response inhibition and WM. We also hypothesized that training would lead to “near transfer” (changes in performance on non-adaptive versions of training tasks) and “far transfer” (changes in performance on unrelated WM and inhibition tasks). At a broader level, we hypothesized that training would reduce rumination, and would improve reappraisal, given evidence linking WM capacity with reappraisal ability (Schmeichel et al., 2008). Consistent with the RDoC initiative (Insel et al., 2010), these aims were evaluated in a heterogeneous sample of individuals with high scores on an ERI measure (without regard to specific clinical diagnoses). Symptoms of psychopathology commonly associated with ERI were assessed to characterize the sample.

3. Method

All procedures were approved by the University Institutional Review Board. Participants were recruited through online advertising and flyers distributed to support groups and clinics for specific populations known to have difficulties with ERI. Additional participants included undergraduate students who received extra credit for participation in the study. Potential participants were directed to a website to complete an initial online consent form and the Feelings Trigger Action (FTA) impulsivity scale (described below). Those who obtained an FTA score of 92 or higher (corresponding to an average response of 3.5 on a 5-point scale, one standard deviation above average scores in a validation sample [Carver et al., 2011]) were invited to complete a phone screen with a member of study staff. Exclusion criteria assessed during this call included age outside the study range (18–65); history of traumatic brain injury, brain tumor, or neurological disorders; acute suicidality, or psychotic symptoms. Participants who appeared eligible after the screening phone call were invited to attend an enrollment session.

At the enrollment session, written informed consent was obtained and participants completed the Wechsler Test of Adult Reading (WTAR) to verify an estimated IQ score equal to or greater than 70 (all participants met this criterion). Participants also completed a brief interview to assess history of mental health treatment and self-reported diagnoses. Eligible participants were then randomized to the waitlist or no-waitlist

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