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Comparing cognitive defusion and cognitive restructuring delivered through a mobile app for
individuals high in self-criticism

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Abstract

There are ongoing questions regarding the similarities and differences in the clinical impact and processes of change for cognitive restructuring and cognitive defusion. This clinical component test compared 87 adults high in self-criticism randomized to a cognitive defusion mobile app, restructuring app, or waitlist condition for two weeks. Equivalent improvements were found from the defusion and restructuring apps relative to the waitlist in self-criticism and distress as well as decentering, self-compassion, and dysfunctional attitudes. However, the defusion condition had a more consistent pattern of improvements relative to waitlist. Improvements in cognitive decentering, self-compassion, and dysfunctional attitudes mediated effects for cognitive defusion relative to waitlist. These mediators were inconsistent for cognitive restructuring. Improvements in self-compassion and cognitive decentering correlated with improvements in outcomes in the defusion condition, but not the restructuring condition. Overall, these results suggest mobile apps providing cognitive defusion and cognitive restructuring strategies are equally effective, but work through distinct processes of change.

Keywords: mHealth; acceptance and commitment therapy; cognitive therapy; mindfulness; component analysis.

Comparing cognitive defusion and cognitive restructuring delivered through a mobile app for individuals high in self-criticism

Cognitive behavioral therapies (CBTs) include a wide range of treatment approaches and components (Hayes & Hofmann, 2018). Furthering our understanding of the active effects, functions, and differences between these components is critical for clarifying differences in treatment approaches, identifying when to use what approach with a client, and guiding future treatment development. These analyses are particularly critical at the level of components and mechanisms of change, rather than treatment package, providing a more precise understanding of therapeutic methods that may be used in a wide range of evidence-based practices.

One area that warrants further attention is in examining the differences between more traditional cognitive therapy methods that focus on restructuring maladaptive thoughts (i.e., changing the content of thoughts) and contextual cognitive behavioral therapies that focus on changing how individuals relate to maladaptive thoughts (i.e. changing the function of thoughts)(Hayes, Villatte, Levin & Hildebrandt, 2011). While multiple conceptualizations of cognitive therapy (CT) exist, a major one sees CT as utilizing a range of effective cognitive restructuring strategies that challenge and change maladaptive, irrational thoughts to increase alternate thoughts that are more rational and useful (Beck & Haigh, 2014). In contrast, contextual CBTs such as acceptance and commitment therapy (ACT) use methods such as cognitive defusion strategies that aim to reduce the literal functions of thoughts so that they have less of a dominant impact on experiences and actions, without necessarily changing their form or content (Hayes, Strosahl & Wilson, 2012). In other words, cognitive defusion aims to help individuals notice thoughts as just thoughts rather than things that are literally true, without having to change them. The differences between cognitive defusion and related methods that aim to alter the

function of thoughts and cognitive restructuring are regularly used as a defining quality in exemplifying differences between traditional CBT and newer contextual CBTs (e.g., Hayes et al., 2011; Segal, Teasdale & Williams, 2004; Wells, 2008).

There has been limited direct research comparing cognitive defusion and restructuring components, and the findings to-date have been somewhat mixed. Overall, component research indicates positive effects in isolation for both cognitive defusion (Levin et al., 2012) and cognitive restructuring relative to control conditions (e.g., Deacon et al., 2011; Yovel, Mor, & Shakarov, 2014). In direct comparison studies, some component studies have found equivalent improvements on primary outcomes between cognitive defusion and cognitive restructuring (Deacon et al., 2011; Yovel et al., 2014). That said, some component studies have found stronger effects for cognitive defusion relative to restructuring on outcomes including negative thought frequency and discomfort (Larsson et al., 2016) and eating behaviors (Moffitt et al., 2012). Such direct comparisons between the efficacy of cognitive restructuring and defusion may start to clarify distinctions between components and contexts in which one is more or less effective than the other. However, of more relevance to understanding if and how these treatment components function differently is research testing whether cognitive defusion and restructuring work through distinct mediating mechanisms.

Preliminary component research suggests that cognitive defusion and restructuring work through distinct mechanisms in ways consistent with their corresponding theories (Beck & Haigh, 2014; Hayes et al. 2012). Component studies have found that cognitive defusion produces greater improvements than restructuring on the importance of, believability of, and willingness to have negative thoughts (Deacon et al., 2011; Larsson et al., 2016), while greater improvements have been found in cognitive restructuring than cognitive defusion on thought accuracy (Deacon

et al., 2011). Furthermore, studies have found that reductions in the importance of thoughts and improvements in acceptance/defusion from thoughts correlate with improvements in outcomes for cognitive defusion, but not cognitive restructuring (Deacon et al. 2011; Yovel et al., 2014). In contrast, increases in the importance of thoughts and reappraisal of thoughts correlate with improvements in outcomes for cognitive restructuring, but not defusion (Deacon et al., 2011; Yovel et al., 2014). Thus, preliminary component research suggests cognitive defusion produces greater effects on decreasing the importance/believability of thoughts that account for effects on outcomes, while cognitive restructuring produces benefits primarily through changes in the reappraisal of thoughts (and possibly through increases in the importance of thoughts; Deacon et al., 2011).

One limitation of past research is the use of very brief single intervention sessions as short as 9 minutes (Yovel et al., 2014) or approximately 600 words (Larsson et al., 2016), sometimes emphasizing a single technique (e.g., “milk, milk, milk” Deacon et al., 2011). This limitation is consistent with a laboratory design in which the independent variable is constrained for experimental control and precision at the expense of external validity. In addition, most of these studies used general, non-distressed samples that raise questions regarding generalizability to clinical contexts (Larsson et al. 2016; Moffitt et al., 2012; Yovel et al., 2014), although preliminary component tests have been conducted with participants elevated on body image concerns (Deacon et al., 2011) and diagnosed with social anxiety (Barrera et al., 2016). Additional clinical component tests are needed with more extensive interventions and distressed samples to further clarify the active effects and mechanisms of change for cognitive defusion and restructuring.

Individuals who report high, chronic levels of self-criticism may be a particularly relevant population to conduct clinical component tests comparing cognitive defusion and cognitive restructuring. Self-criticism is a common feature and contributor for a range of psychological disorders (e.g., Gilbert & Procter, 2006; Zelkowitz & Cole, in press). Self-criticism is a relevant cognitive target that has been effectively treated with both traditional cognitive therapy (e.g., Cox et al., 2002; Rector et al., 2000) and ACT protocols (Luoma & Platt, 2015). In addition to changing the believability/importance of self-critical thoughts, preliminary research also suggests ACT may increase self compassion as a more adaptive way of relating to oneself that enhances psychological functioning (Luoma & Platt, 2015), which is the primary target in another contextual CBT specifically designed for highly self-critical clients, compassionate mind training (Gilbert & Procter, 2006). Thus, this study was conducted with a sample of individuals reporting elevated self-criticism, providing a distressed group for whom cognitive defusion and restructuring are particularly relevant.

Mobile apps offer a promising method for clinical component tests. There is a preliminary, but promising research literature suggesting contextual and traditional CBT interventions can be effectively delivered through mobile apps (Torous et al., 2017). Mobile apps provide experimental control with regards to automated, consistent delivery of therapeutic strategies, while minimizing variables related to human contact as an additional unmeasured or potentially confounded variable. Although minimizing human contact variables (e.g., therapeutic alliance, common factors) may reduce intervention effect sizes and generalizations of findings to in-person therapy, this provides a targeted and efficient method for testing components, with fewer, more resource intensive therapist-delivered component tests being subsequently conducted to confirm generalizations. Furthermore, mobile apps can be used to deliver

interventions at a higher dosage than typical component tests, and in relation to practicing therapeutic strategies in the context of one's day-to-day life. Finally, such clinical component research can concurrently serve to build upon the limited evidence base for CBT apps, providing a precise evaluation of delivering specific CBT components through apps.

The current clinical component study compared cognitive defusion and cognitive restructuring delivered through a mobile app over 2 weeks relative to a waitlist condition in a sample of individuals struggling with self-criticism. The first study prediction was that cognitive defusion and cognitive restructuring would produce equivalent improvements in self-criticism and psychological functioning relative to the waitlist. The second prediction was that cognitive defusion would produce greater improvements on cognitive decentering, fusion, and self-compassion relative to cognitive restructuring, while cognitive restructuring would produce greater improvements on dysfunctional attitudes and reappraisal. The third prediction was that changes in cognitive decentering, fusion, and self-compassion would relate to improvements in outcomes in the defusion condition, while changes in dysfunctional attitudes and reappraisal would relate to improvements in the restructuring condition.

Methods

Participants

A sample of 87 adults high in self-criticism participated in the study. Eligibility criteria included being 18 or older, owning an iPhone or Android smartphone, interested in self-help through a mobile app, and reporting a score of 19 or higher on the Inadequate-Self subscale of the Forms of Self-Criticism and Self-Reassurance Scale (FSCRS; Gilbert et al., 2004). This cutoff score is one point above the median in non-clinical samples and one *SD* below the mean in clinical samples (Baiao et al. 2015).

Recruitment was conducted in the Mountain West region of the United States through flyers and online advertisements distributed throughout local communities and universities. Potential participants were directed to either an online screener for clinical trials being offered in the laboratory, or to a screener for this study specifically. Of the 107 individuals who completed the study-specific screening, a final sample of 87 were enrolled (see Figure 1).

The final sample was 68.9% female with a mean age of 22.76 ($SD = 7.02$, Range = 18–52). The sample was 91% White non-Hispanic, 6% Hispanic/Latino, 2% Asian, and 1% Portuguese. The median household annual income was \$20,000-\$40,000 with 13% reporting \$100,000 or more. In terms of employment status, 39% were employed part-time, 35% were a full time student, 14% were unemployed, 9% were employed full-time, 2% were a stay-at-home parent, an 1% were on disability. The sample reported clinical levels of self-criticism with a mean FSCRS inadequate-self score of 35.02 ($SD = 5.56$), which is one SD above the mean score in clinical samples ($M = 27.47$, $SD = 7.51$; Baiao et al. 2015). In terms of psychological distress, 82% had moderate or greater depression, anxiety, and/or stress symptoms based on cutoff scores for the Depression, Anxiety, and Stress Scale (DASS; Lovibond & Lovibond, 1995).

Procedures

Overview. Participants completed all procedures online. After completing the online pre-screening and informed consent, participants completed a baseline assessment through Qualtrics. Participants were automatically randomized by Qualtrics to the cognitive defusion, cognitive restructuring, or waitlist condition. Participants were instructed to complete condition specific activities over the following 2 weeks. After 2 weeks, an online post assessment was provided.

Waitlist condition. Those randomized to waitlist were instructed to wait 2 weeks for the post assessment. After completing the post assessment, waitlisted participants were provided access to the apps.

Mobile app conditions. Participants randomized to the app conditions were immediately directed to a 20-minute online training through Qualtrics. The online training was designed to increase app adherence by providing a rationale for how it might help with self-criticism, having participants try out specific app exercises, and describing how to access app features. Content was tailored to either cognitive defusion or restructuring based on assigned condition, although the overall structure was similar across conditions. Participants were then instructed on how to install the mobile app.

Both mobile apps were delivered through LifeData, which can deliver customized native apps developed by researchers. LifeData provides a host of features for delivering app interventions including sophisticated notification tools, interactive features (e.g., multiple choice, open text), skip logic and branching, and embedding multiple, distinct sessions into a single app. As a native app, notifications are provided directly through the phone and sessions can be accessed when offline. Participants' app usage data is stored in a secure server accessible to researchers.

The defusion and restructuring apps were balanced on types of exercises provided. Each app included two types of daily notifications. Three random notifications were provided each day between 9am and 9pm, asking users to complete a brief check-in assessing if they were struggling with difficult thoughts, and if so, recommending app skills to practice. Participants were also prompted at 8pm each day to complete a diary assessing frequency and responses to self-critical thoughts that day.

Participants could also access a menu of skill coaching sessions at any time to practice cognitive techniques/exercises. First, each condition provided 19 “quick tips” (1-2 sentence strategies that can be applied in the moment). Second, each condition provided a “reflect on a thought” interactive exercise, which used a thought monitoring structure to help participants notice difficult thinking patterns and how they might use skills in future situations. Third, each condition provided an interactive session to notice if they are currently struggling with a thought and how to apply skills to address it (e.g., identifying cognitive distortions and challenging them *or* noticing fusion and how to defuse).

The cognitive defusion app included two additional skill sessions – “practice flexibility” in which users went through a set of brief, interactive defusion skills and “your mind is like...” in which users selected from a variety of metaphors for cognitive fusion/defusion and applied them to difficult thoughts. The cognitive restructuring app included three additional skill sessions – “what’s the evidence” in which users completed a set of questions to examine the evidence for and against a thought, “alternate thoughts” in which users could read examples of more rationale, balanced thoughts that might apply to them, and “taking perspective” in which users answered questions to reframe and de-catastrophize negative thoughts about a situation.

Although the features for the cognitive restructuring and cognitive defusion apps were relatively balanced, the content was highly distinct and carefully reviewed to avoid overlap. Cognitive defusion content focused on teaching how to notice when they were fused with thoughts, identify the effects of fusion, and practice defusion strategies to interact with thoughts more flexibly. Cognitive restructuring content focused on teaching app users how to recognize cognitive distortions, identify the negative impact of irrational thoughts, and practice strategies to challenge and change these thoughts to be more balanced and realistic.

Participants were sent a check-in email within 48 hours of being assigned the app to address any potential problems. Additional standardized email contacts were provided if a participant stopped using the app.

Measures

Primary outcome measure. The 22-item *Forms of Self-Criticism and Self-Reassurance Scale* (FSCRS; Gilbert et al., 2004) includes subscales assessing inadequate self-criticism (FSCRS-I; a tendency to judge/devalue oneself), hatred self-criticism (FSCRS-H; a more severe self-criticism and self-directed contempt) and self-reassurance (FSCRS-SR; an alternate positive way of relating to oneself). This measure has demonstrated good reliability and validity in past studies (Baiao et al. 2015; Gilbert et al., 2004). Internal consistency was adequate in the current study (FSCRS-I $\alpha=.91$, FSCRS-H $\alpha=.73$, FSCRS-SR $\alpha=.90$).

Secondary outcome measures. The *Depression, Anxiety and Stress Scale-21* (DASS-21; Lovibond & Lovibond, 1995) total score was used as a measure of psychological distress. The 5-item *Work and Social Adjustment Scale* (WSAS; Mundt et al., 2002) assessed the degree to which self-criticism interferes with psychosocial functioning (e.g., ability to work, complete home tasks). In the current study, internal consistency was adequate for the DASS ($\alpha=.92$) and WSAS ($\alpha=.81$).

Cognitive defusion process measures. The 12-item *Self-Compassion Scale-Short Form* (SCS-SF; Raes et al., 2011) was used to assess self-compassion. This short-form version assesses self-kindness, self-judgment, common humanity, isolation, mindfulness, and over-identification, with the total score used for the current study. The 11-item *Experiences Questionnaire* (EQ; Fresco et al., 2007) was used as a measure of cognitive decentering, a highly overlapping construct with cognitive defusion involving observing thoughts as just thoughts. The 7-item

Cognitive Fusion Questionnaire (CFQ; Gillanders et al., 2014) measured cognitive fusion, the inverse process to defusion in which thoughts dominate actions and experiences. In this study, internal consistency was adequate for the SCS-SF ($\alpha=.81$), EQ ($\alpha=.80$), and CFQ ($\alpha=.90$).

Cognitive restructuring process measures. The 11-item *Dysfunctional Attitude Scale-Perfectionism/Performance Evaluation subscale* (DAS-PPE; de Graaf et al., 2009) assessed changes in self-critical related dysfunctional attitudes. The 6-item cognitive reappraisal subscale of the *Emotion Regulation Questionnaire* (ERQ-CR; Gross & John, 2003) assessed use of reappraisal as a coping strategy. In this study, internal consistency was adequate for the DAS-PPE ($\alpha=.87$) and ERQ-CR ($\alpha=.90$).

Program satisfaction. The 10-item *System Usability Scale* (SUS; Brooke, 1996) assessed app usability and acceptability. The SUS is a widely used measure of online program usability (Bangor et al., 2008). In this study, the internal consistency of the SUS was $\alpha=.85$.

Data Analysis Plan

Mixed-model repeated-measures analyses (MMRM) with unstructured covariance matrices were used to test for between group differences on outcome and process measures over time. MMRM allows for an intent-to-treat approach, including all available data and modeling any missing data for randomized participants. Significant omnibus time by condition interactions were explored with post hoc MMRM time by condition tests with each pair of study conditions. Cohen's *d* effect sizes were calculated for time by condition effects using recommended procedures (Verbeke & Molenberghs, 2000; Wackerly et al., 2008).

Mediational analyses were conducted using the cross product of coefficient test with bootstrapping (Preacher & Hayes, 2004). Mediational models were tested separately for cognitive defusion versus waitlist and cognitive restructuring versus waitlist to explore potential

mediators of each intervention (and given the lack of between group differences that were found between defusion and restructuring). Mediation models were limited to outcome measures that significantly improved in the app condition relative to waitlist and with mediating variables that significantly improved relative to waitlist. Each mediation model included the baseline outcome variable and baseline cognitive reappraisal (due to baseline imbalance) as covariates. Pre to post change scores on process measures were used for each mediator.

Regression analyses further explored differences in processes of change between defusion and restructuring. The interaction between study condition (defusion versus restructuring) and pre-to-post change scores on mediators were regressed on pre-to-post change scores for each outcome. This interaction term tested whether changes in process variables relate to changes in outcome variables differentially between the defusion and restructuring conditions. Regression models included the main effects of study condition and pre-to-post change scores as well as an interaction term.

Results

Preliminary Analyses

Each variable approximated a normal distribution based on skewness and kurtosis values. Out of 87 participants, 69 completed post (79%), with no differences in completion rates between conditions (see Figure 1). With regards to baseline equivalence, there were significant differences between conditions at baseline on the ERQ-CR, $F(2, 82) = 4.65, p = .01$. The waitlist condition was significantly lower on cognitive reappraisal than the restructuring condition, $M_{diff} = -5.89, p < .01$, and defusion condition, $M_{diff} = -4.85, p = .02$. All other demographic and baseline measures were equivalent between conditions. To control for baseline differences on cognitive reappraisal, ERQ-CR was included as a covariate for MMRM analyses.

App Usage and Satisfaction

There was a fairly high rate of app usage with 90% using the defusion app at least once and 93% using the restructuring app at least once. In the defusion condition, participants completed 48.28 app sessions on average over 2 weeks ($SD = 30.02$), including 31.28 prompted check-ins ($SD = 19.01$) and 17.00 skill coaching sessions ($SD = 14.01$). In the restructuring app condition, participants completed 41.71 app sessions on average ($SD = 21.92$), with 28.64 prompted check-ins ($SD = 16.46$) and 13.07 skill sessions ($SD = 9.33$). There were no significant differences in program usage between conditions ($p > .10$), indicating comparable dosage rates for the defusion and restructuring conditions.

Participants provided high usability ratings for both apps on the SUS (Defusion $M = 81.00$, $SD = 14.77$; Restructuring $M = 81.30$, $SD = 11.58$). Similar positive ratings were found for satisfaction items on a 5-point scale from *strongly disagree* to *strongly agree* including “the mobile app was helpful for me in dealing with self-criticism” (Defusion $M = 3.91$, $SD = 1.07$; Restructuring $M = 4.13$, $SD = .97$), individual “the mobile app would be helpful to others struggling with self-criticism” (Defusion $M = 4.05$, $SD = .90$; Restructuring $M = 4.35$, $SD = .71$), and “I would recommend this mobile app to a friend who was struggling (Defusion $M = 3.95$, $SD = 1.09$; Restructuring $M = 4.17$, $SD = 1.11$). There were no differences between the defusion and restructuring conditions on satisfaction and usability items, suggesting comparable satisfaction and credibility.

Between Condition Effects on Outcome Variables

MMRM analyses tested time by condition interactions with all three study conditions, controlling for baseline cognitive reappraisal (due to baseline imbalance). Significant time by condition interactions were found for hatred self-criticism, self-reassurance, psychological

distress, and interference with functioning (see Tables 1 and 2). Cohen's d effect sizes ranged from .46 to .72. The only non-significant time by condition interaction was for inadequate self-criticism.

Post hoc analyses indicated significant time by condition interactions between cognitive defusion and waitlist for all of these outcome measures, such that there were greater improvements with defusion versus waitlist, with medium to large effect sizes between .61 and 1.23. Significant time by condition interactions were also found comparing restructuring versus waitlist for self-reassurance ($d = .92$) and psychological distress ($d = .99$), but not hatred self-criticism or interference with functioning. There were no significant time by condition interactions between cognitive defusion and cognitive restructuring, indicating equivalent improvements in outcomes with the two apps. There was a marginally significant trend, with a medium effect size, for cognitive defusion leading to greater improvements in interference with functioning (WSAS) relative to cognitive restructuring ($p = .053$, $d = .60$).

Between Condition Effects on Process of Change Variables

MMRM analyses controlling for baseline cognitive reappraisal, indicated significant time by condition interactions for dysfunctional attitudes, cognitive decentering, and self-compassion (See Tables 1 and 2). Cohen's d effect sizes ranged from .47 to .83. There were no significant time by condition interactions for cognitive reappraisal or cognitive fusion.

Post hoc analyses found significant time by condition interactions for dysfunctional attitudes, cognitive decentering, and self-compassion between waitlist and defusion (d ranging from .76 to 1.06) as well as between waitlist and restructuring (d ranging from .80 to 1.61). There were no time by condition interactions between cognitive defusion and restructuring.

Thus, participants in the cognitive defusion and restructuring conditions improved more over two weeks relative to the waitlist, but did not differ between the two active conditions.

Mediational Analyses Relative to Waitlist

A series of mediational models were tested with outcome and process measures that improved in the defusion condition relative to waitlist (see Table 3). Results indicated that cognitive decentering, negative attitudes, and self-compassion each significantly mediated the effects of defusion (versus waitlist) on each outcome. Intervention condition no longer predicted post outcomes after controlling for the mediator in all but two models. The proportion of variance in outcomes accounted for by the mediator varied between 28% and 100%. The only exception was that dysfunctional attitudes did not mediate intervention effects on interference with functioning. Thus, the effects of cognitive defusion on psychological outcomes was largely accounted for by its impact on cognitive decentering, negative attitudes, and self-compassion.

Mediational analyses were repeated comparing the restructuring app versus waitlist, but limited to the two significant outcomes that improved between conditions (self-reassurance and psychological distress) (see Table 4). For the restructuring condition, only self-compassion and dysfunctional attitudes were significant mediators, and only for psychological distress, accounting for 20% and 22% of the variance respectively. This appeared to be due in part to non-significant *b* paths, suggesting that changes in decentering, self-compassion, and restructuring did not correlate with changes in outcomes in the restructuring condition versus waitlist.

Comparing Processes of Change for Cognitive Defusion and Restructuring

Regression analyses further explored processes of change between the defusion and restructuring conditions. Regression models tested whether the relation between pre-post

changes on process variables and pre-post changes on outcome variables was moderated by study condition (defusion versus restructuring).

Study condition moderated the relations between pre-post changes in cognitive decentering and pre-post changes in self-reassurance, $F(1, 42) = 6.22, p = .02, R^2 \text{ change} = .10$, as well as decentering and pre-post changes in self-hatred, $F(1, 42) = 6.72, p = .01, R^2 \text{ change} = .11$. In the defusion condition, pre-post improvements in cognitive decentering were significantly correlated with improvements in self-reassurance, $r = .67, p < .001$, and self-hatred, $r = -.70, p = .002$. In the restructuring condition, there was no correlation between changes in decentering and changes in self-reassurance, $r = .03, p = .91$, or self-hatred $r = .05, p = .81$. Thus, changes in cognitive decentering appeared related to changes in outcomes in the defusion condition, but not the restructuring condition.

Study condition also moderated the relations between pre-post changes in self-compassion and pre-post changes in self-reassurance, $F(1, 42) = 13.13, p = .001, R^2 \text{ change} = .19$, self-hatred, $F(1, 42) = 4.54, p = .04, R^2 \text{ change} = .06$, and interference in functioning, $F(1, 42) = 4.25, p = .04, R^2 \text{ change} = .07$. In the defusion condition, pre-post improvements in self-compassion were significantly correlated with improvements in self-reassurance, $r = .71, p < .001$, self-hatred, $r = -.73, p < .001$, and interference in functioning, $r = -.63, p = .002$. In the restructuring condition, there was no correlation between changes in self-compassion and changes in self-reassurance, $r = -.03, p = .89$, self-hatred, $r = -.34, p = .12$, and interference in functioning, $r = -.21, p = .35$. Again these results suggest improvements in self-compassion were related to improvements in the defusion condition, but not the restructuring condition. There were no moderation effects with changes in dysfunctional attitudes and outcomes, suggesting changes in dysfunctional attitudes were relevant to changes in outcomes across conditions.

Discussion

This study compared the treatment effects and processes of change for cognitive defusion and cognitive restructuring in the context of a mobile app clinical component test with individuals struggling with self-criticism. Consistent with predictions, comparable improvements were found on self-criticism and psychological functioning from cognitive defusion and restructuring, both of which outperformed a waitlist condition. There were mixed findings for processes of change. Cognitive defusion and restructuring both produced equivalent improvements in dysfunctional attitudes, cognitive decentering, and self-compassion relative to waitlist, but failed to produce distinct effects on relevant processes. Although there were equivalent between group effects, the processes of change for cognitive defusion and restructuring differed. Most notably, improvements in self-compassion and cognitive decentering correlated with improvements in outcomes within the defusion condition, but not the restructuring condition. Overall, results indicate that cognitive defusion and restructuring both have an active, positive effect on psychological outcomes as an isolated treatment component, but produce these effects through distinct mechanisms.

Consistent with previous research (e.g., Deacon et al., 2011; Levin et al., 2012), this study found that both cognitive defusion and restructuring produced large improvements relative to a waitlist. This study extends prior research through a clinical component test with a distressed sample using a mobile app that supported frequent practice of a variety of cognitive strategies. Furthermore, results indicate that these CBT strategies can be effectively delivered in a mobile app format, providing empirical support for this new medium of delivering CBT.

Previous research directly comparing cognitive defusion and restructuring components have regularly found equivalent positive effects on mental health (Deacon et al., 2011; Yovel et

al., 2014). However, some studies have found stronger effects with cognitive defusion relative to restructuring on eating behaviors (Moffitt et al., 2012) and negative thoughts (Larsson et al., 2016). These findings highlight questions regarding the conditions under which cognitive restructuring or cognitive defusion may be more applicable to clients, which is often the more apt question in comparing two evidence-based strategies. The current results suggest that cognitive defusion and cognitive restructuring are generally equally effective in the context of a mobile app for individuals struggling with self-criticism, although there were some non-significant trends suggesting stronger/more consistent effects with defusion.

Results were mixed with regards to differences in processes of change between cognitive defusion and restructuring. Although defusion produced improvements in cognitive decentering and self-compassion relative to the waitlist, these effects were equivalent with cognitive restructuring. Similarly, although cognitive restructuring produced improvements in dysfunctional attitudes relative to waitlist, so did cognitive defusion. Furthermore, both cognitive defusion and restructuring failed to impact a key process of change relative to waitlist (cognitive fusion and reappraisal respectively). Although this may be due to measurement challenges in assessing cognitive processes, the overall pattern suggests these treatment components may have similarly impacted these theoretically distinct processes. In some ways, this is still theoretically consistent given cognitive defusion developed from the cognitive distancing component within cognitive therapy (Zettle, 2005). That said, while cognitive defusion ends at the distancing step, cognitive restructuring would then aim to change the content of the thought being noticed. Theoretically this would significantly alter the function of noticing thoughts and make these two treatment approaches notably distinct.

However, the direct effect of app conditions on these measures is only one aspect of understanding processes of change. Although two approaches might equally affect a variable, in one case changes may be a primary process through which clinical improvements occurs and in the other case it may be auxiliary and irrelevant to clinical effects. Consistent with this, we found that cognitive defusion and restructuring differed with regards to mediating variables. In the defusion condition, self-compassion, cognitive decentering, and dysfunctional attitudes all mediated effects on self-criticism and functioning. In contrast, cognitive decentering did not mediate effects for restructuring, and self-compassion and dysfunctional attitudes only mediated some restructuring effects. Furthermore, changes in self-compassion and decentering correlated with changes in psychological outcomes in the defusion, but not the restructuring condition. Overall, this suggests that although cognitive restructuring and defusion both improve self-compassion and decentering, these processes are only relevant for improving psychological functioning with defusion. In other words, defusion works through improving self-compassion and decentering, but this is not the case for cognitive restructuring.

It was less clear what mediated the effects of the cognitive restructuring app. The equivalent effects on self-criticism relative to the cognitive defusion app suggests that cognitive restructuring had an active clinical effect. However, changes in dysfunctional attitudes did not consistently mediate treatment effects and the cognitive restructuring app failed to differentially improve the use of cognitive reappraisal as a coping strategy. One potential explanation is that neither of these measures, possibly due to their global, trait-like quality, were sensitive to detecting relevant processes of change for this study (i.e., changes in dysfunctional attitudes and use of restructuring strategies). In contrast, previous component studies that have found evidence for cognitive processes of change in cognitive restructuring used tailored, contextualized

questions to assess features such as reappraisal and accuracy of target thoughts (Deacon et al., 2011; Yovel et al., 2014). Alternatively, the effects of the cognitive restructuring app may have actually occurred through different, unmeasured processes of change such as changes in perceived accuracy of thoughts, self-efficacy in coping with cognitions, or potentially even nonspecific methods and placebo effects from receiving an apparently helpful app. Future research would benefit from the use of more refined measures of cognitive therapy processes of change and an expanded set of potential mediators besides changes in maladaptive cognitions.

This is the first clinical component study we are aware of to use a mobile app to evaluate and compare treatment components. One of the biggest challenges with treatment component research is balancing feasibly conducting the range of studies with high internal validity needed to understand how treatment components function and compare, with external validity challenges in generalizing these findings to conducting therapy with various clinical populations (Kazdin, 1978; Levin et al., 2012). Mobile apps offer solutions to some parts of this challenge by providing a more intensive dosage of a component intervention (versus single session laboratory interventions), that can be tightly controlled and consistently implemented through an automated format, and with relatively low resource costs for an iterative, progressive program of research. Furthermore, with the growth of CBT mobile apps and websites for mental health concerns, such app-based component studies have direct generalizability to similar online self-guided mental health services. This is particularly critical given the development and dissemination of these mobile apps currently, and will likely to continue to, substantially outpace research, indicating a need for more generalizable principles (e.g., does this include components known to be effective in an app format?) to determine the degree to which any given mobile app is evidence-based (Torous et al., 2017). We hope that this study provides an example of, and encourages other

research, in testing and comparing treatment components delivered through apps to continue to build a progressive knowledge base for the isolated and combined effects of CBT components, and delivery of components in mobile app formats. This study sought to add to the literature comparing cognitive defusion and restructuring CBT components through the use of a clinical sample of adults high in self-criticism. We identified only two previous studies comparing cognitive defusion and restructuring in more clinical samples including individuals with elevated body image concerns (Deacon et al., 2011) and diagnosed with social anxiety disorder (Barrerra et al., 2016). Testing the impact of CBT components in more clinical samples is important to determine the generalizability of findings, particularly for components designed to target pathological processes. Although, it is worth noting that a previous meta-analysis of ACT component studies found no differences on outcomes between studies using non-distressed, convenience samples and studies using at-risk or clinical sample (Levin et al, 2012). In addition to confirming limits to generalizability, the use of specific clinical samples may also be relevant in identifying client variables that moderate the efficacy and function of cognitive defusion and restructuring methods (e.g., if cognitive restructuring is more effective than defusion for certain problem areas).

There are some notable limitations with this study. First, the study had a relatively short time window of two weeks. This was decided for experimental control to maintain a consistent intervention dosage and proximal assessment window. Arguably this also provided an externally valid evaluation of cognitive defusion and restructuring in terms of the amount of skills taught and practiced. For example, an eight week cognitive defusion intervention that mirrored the dosage of a standard ACT protocol would be very different from the amount and types of defusion strategies taught when included as a component of a protocol. Yet, two weeks may have

been too short to detect differences between treatment components and the effects of mastery of these skills (rather than skill exposure). Future studies would benefit from a follow up assessment to examine how effects maintain or change over time as well as considering longer testing periods for component app interventions. The study also did not include a placebo-control condition. Thus, it is unclear whether positive effects from defusion and restructuring relative to waitlist represent active intervention effects versus other methodological factors relevant to any seemingly helpful psychological skill.

The study was conducted by ACT researchers, which introduces potential bias. For example, the study found clearer mediators for cognitive defusion than cognitive restructuring. Although concerns have been raised regarding mediators for cognitive restructuring (Longmore & Worrell, 2007), the current findings may also reflect biases and differing expertise areas in measure selection. Similarly, the two apps may have differed in quality and fidelity to their respective approaches, with cognitive restructuring being more likely to be ineffectively implemented by the researchers. Of note, a cognitive therapy expert did not review the cognitive restructuring mobile app, which is a further limitation in terms of ensuring that the restructuring app was implemented competently and with fidelity to cognitive therapy principles. Equally high rates of program satisfaction and usage were found, suggesting we were at least successful in delivering two equivalently high quality, engaging apps. Finally, this study was not pre-registered, which is an effective way to reduce bias related to selective analysis and outcome reporting.

Overall, this study found that although cognitive defusion and restructuring are equally effective when delivered as a mobile app for individuals struggling with self-criticism, these treatment components differ with regards to their processes of change. Furthering our

understanding of the shared and distinct processes through which restructuring and defusion work is critical for guiding when each strategy might be more helpful, and relevant differences in their larger respective treatment packages.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Table 1. *MMRM estimated marginal means with full ITT sample.*

Measure	Defusion App		Restructuring App		Waitlist	
	Pre <i>M</i> (<i>SE</i>)	Post <i>M</i> (<i>SE</i>)	Pre <i>M</i> (<i>SE</i>)	Post <i>M</i> (<i>SE</i>)	Pre <i>M</i> (<i>SE</i>)	Post <i>M</i> (<i>SE</i>)
<i>Outcome Measures</i>						
Hatred Self-Criticism (FSCRS-H)	13.57 (.87)	11.01 (1.01)	12.15 (.96)	11.03 (1.07)	13.21 (.88)	13.81 (1.01)
Inadequate Self-Criticism (FSCRS-I)	35.09 (1.18)	29.30 (1.66)	34.03 (1.31)	29.70 (1.72)	36.65 (1.20)	34.77 (1.64)
Self-Reassurance (FSCRS-SR)	22.56 (1.04)	25.97 (1.15)	21.58 (1.15)	25.03 (1.23)	21.93 (1.06)	22.22 (1.15)
Psychological Distress (DASS)	55.12 (5.04)	34.27 (4.90)	52.74 (5.52)	37.94 (5.32)	55.58 (5.12)	55.72 (4.90)
Interference with Functioning (WSAS)	27.46 (1.71)	21.45 (1.94)	25.52 (1.88)	23.61 (2.07)	27.49 (1.73)	26.99 (1.94)
<i>Process Measures</i>						
Dysfunctional Attitudes (DAS-PPE)	45.22 (2.62)	38.23 (3.16)	50.61 (2.89)	44.75 (3.35)	43.79 (2.66)	44.75 (3.35)
Cognitive Decentering (EQ)	31.50 (1.00)	37.59 (1.23)	30.14 (1.10)	37.00 (1.29)	30.27 (1.01)	30.24 (1.22)
Self-compassion (SCS)	27.66 (1.31)	33.12 (1.57)	24.57 (1.44)	29.68 (1.66)	26.76 (1.33)	27.49 (1.56)
Cognitive Reappraisal (ERQ-CR)	26.20 (1.43)	30.27 (1.45)	27.32 (1.46)	28.89 (1.46)	21.43 (1.46)	23.74 (1.49)
Cognitive Fusion (CFQ)	35.05 (1.46)	30.33 (1.57)	37.31 (1.60)	33.03 (1.68)	37.44 (1.48)	36.06 (1.56)

Note: Estimated marginal means and standard errors are based on MMRM analyses using ERQ-CR as a covariate (except for the ERQ-CR row). FSCRS-H, FSCRS-I, DASS, WSAS, DAS, and CFQ are scored such that higher scores indicate worse distress/problems. FSCRS-SR, SCS, and EQ are scored such that higher scores indicate greater positive functioning/lower problems.

Table 2. *MMRM results with the full ITT sample.*

Measure	Time x Condition		Time x Condition Cohen's <i>d</i>		
	<i>F</i>	<i>d</i>	Defusion vs. Restructuring	Defusion vs. Waitlist	Restructuring vs. Waitlist
<i>Outcome Measures</i>					
Hatred Self-Criticism (FSCRS-H)	4.58*	.53	.41	.93**	.59†
Inadequate Self-Criticism (FSCRS-I)	2.20	.37			
Self-Reassurance (FSCRS-SR)	3.61*	.46	-.01	.61*	.92**
Psychological Distress (DASS)	8.55**	.72	.38	1.23***	.99**
Interference with Functioning (WSAS)	4.05*	.50	.60†	.83*	.25
<i>Process Measures</i>					
Dysfunctional Attitudes (DAS-PPE)	3.61*	.47	.11	.76*	.80*
Cognitive Decentering (EQ)	11.72***	.83	-.12	1.06**	1.61***
Self-compassion (SCS)	4.25*	.51	.07	.88**	.80*
Cognitive Reappraisal (ERQ-CR)	.69	.20			
Cognitive Fusion (CFQ)	2.24	.37			

Notes: † $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$. Time by condition tests were conducted with baseline ERQ-CR as a covariate except for the analysis on cognitive reappraisal. Negative effect size scores indicate effects opposite to predictions (i.e., worsening of outcomes within conditions, Defusion app post scores < Restructuring app post scores < Waitlist post scores).

Table 3. Mediation analysis results for process and outcome measures that significantly improved in the defusion versus waitlist condition.

	<u>a path</u> X-M	<u>b path</u> M(X)-Y	<u>c path</u> X-Y	<u>c' path</u> X(M)Y	<u>Products of coefficients</u>			Proportion mediated (1-c'/c)
					Point estimate	SE	Bootstrapping 95% CI	
<i>Cognitive Decentering (EQ) Mediation Model</i>								
Hatred Self-Criticism (FSCRS-H)	-3.60***	3.83***	-2.40*	-.53	-2.35	.99	-4.61, -.69	78%
Self-Reassurance (FSCRS-SR)	-3.84***	-5.11***	1.84†	-.62	3.45	1.32	1.28, 6.69	100%
Psychological Distress (DASS)	-3.81***	3.61***	-3.22**	-1.41	-10.30	3.69	-18.63, -4.22	56%
Interference with Functioning (WSAS)	-3.90***	4.87***	-2.23*	.16	-5.32	1.82	-9.50, -2.23	100%
<i>Self-compassion (SCS) Mediation Model</i>								
Hatred Self-Criticism (FSCRS-H)	-2.86**	5.15***	-2.40*	-.69	-2.27	1.09	-5.05, -.60	71%
Self-Reassurance (FSCRS-SR)	-2.65*	-4.36***	1.84†	.38	2.15	1.11	.32, 4.94	79%
Psychological Distress (DASS)	-2.62*	2.58**	-3.33**	-2.31*	-5.41	3.09	-13.95, -.82	31%
Interference with Functioning (WSAS)	-2.66*	4.79***	-2.23*	-.72	-3.58	1.60	-7.08, -.87	68%
<i>Dysfunctional Attitudes (DAS-PPE) Mediation Model</i>								
Hatred Self-Criticism (FSCRS-H)	2.29*	-3.41**	-2.40*	-1.39	-1.37	.74	-3.14, -.14	42%
Self-Reassurance (FSCRS-SR)	2.27*	2.76**	1.84†	.95	1.30	.92	.12, 3.77	48%
Psychological Distress (DASS)	2.38*	-2.85**	-3.33**	-2.39*	-5.33	3.20	-15.16, -.93	28%
Interference with Functioning (WSAS)	2.68**	-2.25*	-2.23*	-1.29	-2.00	1.57	-6.12, .09	

† $p < .10$, * $p < .05$; ** $p < .01$; *** $p < .001$. X-M = treatment condition and mediator, M(X)-Y = Mediator and outcome controlling for treatment condition, X-Y = treatment condition and outcome, X(M)Y = Treatment condition and outcome controlling for mediator. *t*-test values are reported for paths tested.

Table 4. Mediation analysis results for process and outcome measures that significantly improved in the restructuring versus waitlist condition.

	<u>a path</u>	<u>b path</u>	<u>c path</u>	<u>c' path</u>	<u>Products of coefficients</u>			Proportion mediated (1-c'/c)
	X-M	M(X)-Y	X-Y	X(M)Y	Point estimate	SE	Bootstrapping 95% CI	
<i>Cognitive Decentering (EQ) Mediation Model</i>								
Self-Reassurance (FSCRS-SR)	-4.40***	-.75	2.90**	1.97†	.26	.33	-.35, .95	
Psychological Distress (DASS)	-4.49***	1.72†	-3.22**	-1.73†	-2.34	1.39	-5.08, .36	
<i>Self-compassion (SCS) Mediation Model</i>								
Self-Reassurance (FSCRS-SR)	-1.87†	-1.67	2.90**	2.38*	.24	.24	-.04, .96	
Psychological Distress (DASS)	-1.87†	2.61*	-3.22**	-2.58*	-1.42	.89	-3.96, -.14	20%
<i>Dysfunctional Attitudes (DAS-PPE) Mediation Model</i>								
Self-Reassurance (FSCRS-SR)	1.85†	2.12*	2.90**	2.32*	.29	.26	-.02, 1.22	
Psychological Distress (DASS)	1.89†	-3.25**	-3.22**	-2.52*	-1.72	1.06	-4.34, -.07	22%

† $p < .10$, * $p < .05$; ** $p < .01$; *** $p < .001$. X-M = treatment condition and mediator, M(X)-Y = Mediator and outcome controlling for treatment condition, X-Y = treatment condition and outcome, X(M)Y = Treatment condition and outcome controlling for mediator. t -test values are reported for paths tested.

Figure caption

Figure 1. Participant flow diagram

