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The Impact of Emotion Regulation Improvements on Intolerance of Uncertainty During Emotion Regulation Therapy

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Abstract

Both intolerance of uncertainty (IU) and impoverished emotion regulation repertoires characterize generalized anxiety disorder (GAD). Across two treatment studies, we explored relationships between two emotion regulation skills, decentering and reappraisal, and IU during emotion regulation therapy (ERT). Participants were treatment-seeking individuals diagnosed with GAD. Study 1 included data from two open trials of ERT ($N = 52$), and Study 2 examined data from a randomized controlled trial of ERT ($n = 28$) versus a minimal attention control ($n = 25$). IU and emotion regulation skills were measured at pre-, mid-, and post-treatment. Mediation models explored indirect effects of emotion regulation skills on the relationship between time (Study 1) or group (Study 2) and intolerance of uncertainty. Results demonstrated improvements in emotion regulation skills and reductions in IU during ERT. Greater use of reappraisal and decentering was associated with reduced IU over time. Tests of indirect effects suggested that observed between-group differences in IU can be explained by changes in emotion regulation skills. The findings from these studies highlight the utility of non-IU-specific interventions to help individuals tolerate uncertainty. Exploring the impact of emotion regulation skills on IU could lead to improvements in treating GAD.

Keywords. emotion regulation, intolerance of uncertainty, generalized anxiety disorder, treatment

Intolerance of uncertainty (IU) refers to an individual's "dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information" (Carleton, 2016b, p. 31). IU is a transdiagnostic risk factor for several psychopathological disorders, including generalized anxiety disorder (GAD), social anxiety disorder, obsessive-compulsive disorder (OCD), and major depressive disorder (Carleton, 2016b; Shihata et al., 2016). Although the uncertain contexts that elicit aversive emotions and the regulatory mechanisms used to reduce aversive emotions in such conditions may differ across disorders (Boswell et al., 2013), individuals with high IU often use negative self-referential processes (Mennin & Fresco, 2013), including worry, rumination, and self-criticism, to reduce feelings of uncertainty in the short-term (Yook et al., 2016). The use of these regulatory strategies can lead to deficits in reward and threat learning (Bogdan & Pizzagalli, 2006; Forbes et al., 2007; Oglesby & Schmidt, 2017). Indeed, the tendency for individuals with high trait IU to perceive threat in the environment inhibits effective problem-solving and emotion regulation (Ouellet et al., 2019), and IU is linked to higher reactivity in the context of unpredictable threats (Chen & Lovibond, 2016; Papenfuss et al., 2020).

Despite the relevance of IU as a transdiagnostic risk factor, IU was originally conceptualized as a key

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mechanism specifically underlying the maintenance of GAD (Dugas et al., 1998). The original Intolerance of Uncertainty Model (IUM) outlined four variables that influence worry, the hallmark symptom of GAD: 1) IU, 2) positive beliefs about worry (e.g., worrying helps prevent worst-case scenarios), 3) cognitive avoidance (e.g., of feared outcomes), and 4) negative problem orientation (e.g., pessimism about problems and problem-solving abilities) (Dugas et al., 1998). Research supporting this model found that all four components related to GAD severity, though IU was the strongest predictor (Dugas et al., 2007). Further supporting the clinical relevance of IU in GAD, IU has been shown to be an important factor in the development and maintenance of worry (McEvoy & Mahoney, 2012). In an experimental manipulation of IU, Ladouceur and colleagues (2000b) found that participants with increased IU showed higher levels of worry compared to those with decreased IU. In turn, there is evidence that worry mediates the positive relationship between IU and GAD symptoms (Yook et al., 2010).

In addition to experimental exploration of IU as a predictor of generalized anxiety symptoms and severity, intervention research has also examined changes in IU during treatment for GAD (see Robichaud, 2013). Indeed, a cognitive behavioral therapy (CBT) for GAD that explicitly targets IU as one of four primary treatment components (i.e., IU, positive beliefs about the function of worry, negative problem orientation, cognitive avoidance; CBT-IU) has received empirical support (e.g., Dugas et al., 2010; Ladouceur et al., 2000a; Robichaud, 2013). Early iterations of this treatment demonstrated that IU decreased concurrently with GAD symptoms (e.g., worry), with gains maintained at 12-month follow-up (Dugas & Ladouceur, 2000; Ladouceur et al., 2000a). At least five randomized controlled trials of CBT-IU demonstrated efficacy for the reduction of symptoms of GAD (Dugas et al., 2010; Dugas et al., 2003; Gosselin et al., 2006; Ladouceur et al., 2000a; van der Heiden et al., 2012). In a clinical case replication series ($N = 7$), a version of CBT-IU to treat GAD that exclusively targeted IU demonstrated preliminary efficacy to significantly reduce GAD symptoms, with gains maintained after six months (Hebert & Dugas, 2019). Moreover, there is evidence that CBT protocols that do not explicitly target IU may produce comparable reductions in IU for individuals with GAD (van der Heiden et al., 2012). McEvoy and Erceg-Hurn (2016) reviewed three CBT protocols for mood and anxiety disorders to explore associations between changes in IU, negative self-referential processes, and symptom relief. Among participants with GAD, reductions in IU across treatment were associated with lower negative self-referential processes and greater symptom improvement. Similarly, decreased IU significantly mediated subsequent reductions in the frequency of worry in a computer-assisted individual CBT protocol for GAD (Bomyea et al., 2015). Reductions in IU also significantly mediated reductions in worry from pre- to post-group CBT for GAD (Torbit & Laposa, 2016).

Emotion regulation is also commonly investigated in the literature on the maintenance and treatment of GAD. Indeed, higher worry is associated with lower emotion regulation capacities (e.g., Salters-Pedneault et al., 2006), such that individuals with GAD experience impoverished emotion regulation repertoires to cope with their distress (Mennin & Fresco, 2015; Mennin et al., 2009) and implement adaptive regulatory efforts less successfully than healthy controls (Aldao & Mennin, 2012). In light of these findings, it is unsurprising that multiple cognitive behavioral treatments have begun to integrate emotion regulation skill-building as a key component (Blackledge et al., 2001; Fenn & Byrne, 2013; Hoet et al., 2018; Linehan & Wilks, 2015; Ortigo et al., 2020; Sakiris & Berle, 2019; Treanor et al. 2011; Watkins, 2018). Two emotion regulation skills commonly taught across CBTs are decentering, or the process by which internal experiences (e.g., thoughts, feelings, memories) are observed with healthy psychological distance (Bernstein et al., 2015), and reappraisal, or the reinterpretation of situations to change their emotional significance (Gross, 1998). There is evidence that treatments for GAD lead to improvements in decentering (Hoge et al., 2015) and reappraisal (Andreescu et al., 2015), and that these emotion regulation skills are mechanisms of change in the treatment of anxiety disorders, including GAD (Hayes-Skelton & Marando-Blanck, 2019; Hoge et al., 2015; O'Toole et al., 2019b; Smits et al., 2012). For example, Hayes-Skelton and colleagues (2015) found a negative association between changes in decentering and anxiety symptoms. Findings from this study also suggest that increases in decentering temporally precede decreases in GAD symptoms within both acceptance-based behavioral therapy and applied relaxation treatments (Hayes-Skelton et al., 2015).

In a review of GAD conceptual models, Riskind (2005) suggested further exploration of the observed relations among IU, emotion dysregulation, and symptoms of GAD (e.g., worry). Since that time, researchers investigated the contribution of the different variables of the IUM and emotion regulation to explore the role of emotion dysregulation in the maintenance of worry and heightened IU (Ouellet et al., 2015; Ouellet et al., 2019). Specifically, Ouellet and colleagues (2019) found that limited access to emotion regulation strategies partially mediated the relationship between IU and the tendency to worry. Similarly, in a cross-sectional study of psychologically healthy participants, IU was inversely related to the emotion regulation skill of mindful acceptance and partially mediated the relationship between mindful acceptance and worry (Papenfuss et al., 2020). This research suggests that IU is associated with emotion regulation difficulties, though the cross-sectional nature of the indirect effects in these studies precludes conclusions about these relationships over time. Although there is some recent evidence that IU can reduce an individual's capacity to use reappraisal (Shu et al., 2021), the impact of emotion regulation skill-building on IU has not yet been explored longitudinally (Tanovic et al., 2018), particularly in the treatment context (Robichaud, 2013; Sahib et al., 2023).

Taken together, there is evidence that CBTs for GAD reduce IU from pre- to post-treatment (McEvoy & Erceg-Hurn, 2016), and prior research suggests that IU and emotion regulation skills deficits are associated in individuals with GAD (Ouellet et al., 2019). Emotion regulation skill-building is a central component of cognitive behavioral interventions and there is evidence that reappraisal and decentering mediate GAD symptom reduction during treatment (Hayes-Skelton et al., 2015; O'Toole et al., 2019b). Given these findings, emotion regulation skills may serve as important mediators of IU reductions during treatment for GAD. Emotion regulation therapy (ERT), an affect science-based intervention that utilizes emotion regulation skills to reduce negative self-referential processes for individuals with GAD, presents an opportunity to explore this possibility (Renna et al., 2017). ERT shares many features of traditional and contemporary CBTs, including an emphasis on skill-building, to facilitate therapeutic change (Clayton et al., 2021). Specifically, ERT teaches mindful emotion regulation skills, including decentering and reappraisal, throughout the first half of treatment, which are then used to facilitate values-based action during the second half of treatment (Renna et al., 2017).

To date, three open trials and two randomized controlled trials (RCTs) have demonstrated the clinical efficacy of ERT to treat individuals with distress disorders (e.g., GAD) or those experiencing distressing contexts (e.g., cancer caregivers; Panjwani et al., 2019) as measured by clinical response and end state functioning (Applebaum et al., 2018; Mennin et al., 2018; Mennin et al., 2015; O'Toole et al., 2019a; Renna et al., 2018). Findings across ERT trials also indicate consistent, negative correlations between worry and emotion regulation skills during ERT, as well as decreases in worry and increases in decentering and reappraisal (Mennin et al., 2015; Mennin et al., 2018; Renna et al., 2018). Evidence further suggests that emotion regulatory mechanisms, including decentering and reappraisal, not only change over the course of ERT, but also precede and drive symptom reduction (Mennin et al., 2018; O'Toole et al., 2019b). Although past trials have shown ERT to improve GAD symptoms and increase emotion regulation skills, the impact of ERT on IU is unknown. By teaching skills to help individuals with GAD better manage their emotions, we may observe a reduction in IU.

The Current Study

This paper presents secondary analyses of three prior ERT trials to explore the relationships between decentering and reappraisal emotion regulation skills and IU throughout treatment for individuals diagnosed with GAD. Study 1 includes data from two open trials of ERT (Mennin et al., 2015; Renna et al., 2018), and Study 2 includes data from an RCT of ERT compared to a minimal attention control (MAC) (Mennin et al., 2018). Data from these trials exploring the relationships among changes in worry, emotion regulation, GAD severity, and other related constructs have been published elsewhere (Mennin et al., 2015; Mennin et al., 2018; Renna et al., 2018). For both studies in the current paper, we hypothesized that 1) decentering and reappraisal skills would increase, and IU would decrease over time during ERT. In Study 1, we also hypothesized that 2) there would be an indirect effect of treatment (time) on IU through decentering and reappraisal emotion regulation skills. Additionally, in Study 2, we hypothesized that 3) individuals actively receiving ERT would experience a larger decrease in IU over time compared to individuals in the MAC condition and 4) there would be an indirect effect of group (ERT vs. MAC) on IU through decentering and reappraisal. Specifically, we expected that individuals receiving ERT (compared to MAC) would report increased emotion regulation skills, which in turn would contribute to lower IU.

Study 1: Methods

Participants

Participants were 52 (M_{age} = 28.02; *SD* = 10.57) treatment-seeking individuals across two open-trials of ERT (Mennin et al., 2015; Renna et al., 2018). Both trials were conducted at universities in the northeastern United States; Trial 1 (*n* = 21) was conducted jointly at universities in Philadelphia, PA (*n* = 11), and New Haven, CT (*n* = 10), and Trial 2 (*n* = 31) was conducted at a large, urban university in New York City. Demographics for the combined sample are presented in Table 1 and have been reported separately for the two trials elsewhere (Mennin et al., 2015; Renna et al.,

Table 1. Participant Characteristics and Variables of Interest at Pre-Treatment

	Study 1 (*N* = 52)		Study 2 (*N* = 53)			
			ERT (*n* = 28)		MAC (*n* = 25)	
	M (SD)	*n* (%)	*M* (SD)	*n* (%)	*M* (SD)	*n* (%)
Age	28.02 (10.57)		38.25 (15.59)		39.52 (13.39)	
Gender (% Female)		38 (73%)		20 (71%)		20 (80%)
Race						
White		32 (61%)		25 (89%)		21 (84%)
African American		3 (6%)		0 (0%)		3 (12%)
Asian		6 (12%)		1 (4%)		0 (0%)
Mixed Race		3 (6%)		0 (0%)		0 (0%)
Other		8 (15%)		2 (7%)		1 (4%)
IU	37.53 (9.92)		35.21 (9.93)		34.68 (10.96)	
Reappraisal	21.62 (7.45)		22.60 (6.15)		21.58 (9.18)	
Decentering	28.06 (6.18)		29.46 (6.70)		29.58 (5.17)	

Note. M = mean, SD = standard deviation, % = percentage of participants.

2018). All participants were required to be over 18 years old, able to speak and understand English, and provide informed consent for participation. The primary inclusion criterion for both trials was a DSM-IV diagnosis of GAD. Additional specific inclusion and exclusion criteria can be found in the main trial papers for these studies (Mennin et al., 2015; Renna et al., 2018). Given sociodemographic differences (e.g., age, race) between the two trials, trial was controlled for in all analyses. Specifically, Trial 1 required participants to be 18 years old or older, while Trial 2 enrolled participants aged 18-29. Trial 2 also included a larger percentage of non-white participants (54.8%) than did Trial 1 (14.3%).

Procedures

All participants provided written informed consent and all procedures were approved by the institutions' Institutional Review Boards (IRBs). In both trials, The Anxiety Disorders Interview Schedule, Lifetime version for DSM-IV (ADIS-IV-L; Brown et al., 1994; Trial 1, Site 1) or the Structured Clinical Interview for DSM-IV (SCID-IV; Spitzer et al., 2002; Trial 1, Site 2; Trial 2) was administered at a screening visit to assess for GAD and other comorbid disorders. Interviewers for both trials were clinical psychologists or doctoral students in clinical psychology trained to administer the ADIS-IV-L or SCID-IV. The principal investigator met with interviewers following the screening to review and confirm participants' diagnoses. Participants eligible for the full study were enrolled in 20-session (Trial 1) or 16-session (Trial 2) ERT. CONSORT diagrams for both trials have been published elsewhere (Mennin et al., 2015; Renna et al., 2018), and findings reflect the intent-to-treat sample for both trials. Assessments were administered at pre-, mid-, and post-ERT (Times 1 – 3).

Measures

The Intolerance of Uncertainty Scale – 12 item version (IUS-12; Carleton et al., 2007) measures negative beliefs about and reactions to uncertainty and has demonstrated sound psychometric properties. Lower scores on this measure indicate a greater ability to tolerate uncertainty. Internal consistency for the IUS-12 across the three time points ranged from good to excellent ($\alpha = .89 – .95$).

The Experiences Questionnaire—Decentering Subscale (EQ-D; Fresco et al., 2007) is a 20-item measure assessing decentering, with higher scores indicating a greater ability to utilize this emotion regulation skill. Internal consistency for the EQ-D across the three time points ranged from acceptable to excellent ($\alpha = .70 – .92$).

The Emotion Regulation Questionnaire—Reappraisal Subscale (ERQ-R; Gross & John, 2003) is a six-item measure assessing reappraisal. Higher scores on this measure indicate higher reappraisal usage. Internal consistency for the ERQ-R across the three time points ranged from good to excellent ($\alpha = .81 – .91$).

Data Analysis Plan

All descriptive analyses were conducted using SPSS Version 27. Bivariate correlations tested associations among the main study variables. Independent-sample *t*-tests explored trial differences on variables of interest. Growth models tested whether IU, decentering, and reappraisal changed throughout treatment. Effect sizes were computed using Cohen's *d* with .20, .50, and .80 indicating small, medium, and large effects, respectively.

Multilevel mediation analyses were conducted using the Stata package ml_mediation. This multilevel modeling approach accounts for the non-independence

Table 2. Baseline Correlations Among Study Variables

	Study 1 (N = 52)			Study 2 (N = 53)		
	1	2	3	1	2	3
1. Intolerance of Uncertainty	-			-		
2. Reappraisal	-.13	-		-.43*	-	
3. Decentering	-.22	.11	-	-.53*	.50*	-

Note. *$p < .01$. Intolerance of uncertainty was measured using the 12-item version of The Intolerance of Uncertainty Scale. Reappraisal was measured using the reappraisal subscale of The Emotion Regulation Questionnaire. Decentering was measured using the decentering subscale of The Experiences Questionnaire.

in participants' data (i.e., associations among an individual's scores on the same variable over time) and maximized existing data by including all participants in the analyses, regardless of missing data points (Kenny et al., 2003). Mediation models accounted for "time" at Level 1, nested within the "individual" at Level 2 to explore the mediating effects of emotion regulation skills (i.e., reappraisal and decentering) on the relationship between time and IU. Indirect effects were based on the product-of-coefficients approach, which calculates the product of the *a* path [i.e., the effect of *X* on *M*] and *b* path [i.e., the effect of *M* on *Y*, controlling for *X*]), and represent the average change in *Y*, for every unit change in *X* mediated by *M* (Lee & Preacher, 2013). Standard errors and bias-corrected 95% confidence intervals were computed using 5,000 bootstrapped samples. Bias-corrected confidence intervals that did not include zero were interpreted as statistically significant ($p < .05$). Given the bootstrapped standard error and sample size, effect sizes for indirect effects were computed by transforming the observed coefficients of indirect effects into correlation coefficients (*r*) (Preacher & Kelley, 2011). As per the guidelines in Cohen (1988), effect sizes of .10, .30, and .50 were considered small, medium, and large effects, respectively. All analyses controlled for study trial, based on trial-related differences on demographic and clinical variables of interest.

Study 1: Results

Descriptive Statistics and Covariates

Table 1 provides descriptive statistics and frequencies of all sociodemographic variables. Trials differed by age (t (20.1) = -5.43, $p < .01$) and race (X^2 (4, 52) = 10.29, p = .04), indicating that participants in Trial 2 were significantly younger and more racially diverse than participants in Trial 1. There were no gender differences between trials (p = .68). Table 1 also presents the means and standard deviations of pre-treatment (Time 1) IU, decentering, and reappraisal. Table 2 provides bivariate correlations among reappraisal, decentering, and IU at Time 1. Independent-sample *t*-tests revealed a significant pre-treatment difference between trials on IU (t (49) = 4.81, $p < .001$) and decentering (t (45) = -3.34, $p < .01$). Specifically, the Trial 1 sample had significantly higher decentering and lower IU than the Trial 2 sample at Time 1. There were no pre-treatment differences between Trial 1 and Trial 2 on reappraisal (t (43) = -1.14, p = .26). To capture between-trial differences, trial was included as a covariate in all analyses. Growth models revealed that IU decreased (b = -2.11, SE = .49, $p < .001$, d = .87), reappraisal increased (b = 1.19, SE = .32, $p < .001$, d = .69), and decentering increased (b = 2.26, SE = .36, $p < .001$, d = 1.19) over the ERT treatment course.

Indirect Effects

The relationship between time in ERT and lower IU (*c* path; b = -3.91, SE = .63, $p < .01$) was significant. Additionally, the relationship between time and increased decentering (*a* path; b = 5.10, SE = .62, $p < .01$) was significant, as was the association between increased decentering and lower IU during ERT, controlling for time (*b* path; b = -.37, SE = .09, $p < .01$). There were also significant relationships between time and increased reappraisal (*a* path; b = 3.80, SE = .64, $p < .01$) and between increased reappraisal and lower IU during ERT, controlling for time (*b* path; b = -0.31, SE = .09, $p < .01$). Moreover, both decentering and reappraisal showed significant indirect effects on the relationship between time and IU, as evidenced by confidence intervals not including 0, with effect sizes (*r*) ranging from .36 to .43 (see Table 3). Specifically, decentering accounted for 44% of the relationship between time and IU, while reappraisal accounted for 29% of the relationship.

Given the intercorrelations between emotion regulation skills and IU (e.g., Ouellet, 2019), it is also plausible that IU mediates the relationship between time and emotion regulation skills. As such, inverse models were tested in which IU served as the mediator and emotion regulation skills (i.e., decentering and reappraisal) were the outcomes in separate models. Models testing IU as the mediator of the relationship between time and decentering demonstrated a significant *c* path (b = 5.10, SE = .62, $p < .01$) and *b* path (b = -.26, SE = .07, $p < .01$). Models testing IU as

Table 3. Study 1 Indirect Effects of Proposed Mediators on Primary Outcomes in Both Directions

	B	BSSE	BCLL	BCUL	IE/TE	*r*
IU mediated by						
Decentering	-1.88	0.56	-3.12	-0.88	0.44	0.43
Reappraisal	-1.22	0.45	-2.28	-0.46	0.29	0.36
Decentering mediated by						
IU	1.00	0.39	0.32	1.80	0.20	0.34
Reappraisal mediated by						
IU	0.88	0.38	0.27	1.74	0.25	0.31

Note. BSSE: bootstrapped standard error; BCLL: bias-corrected lower level of 95% confidence interval; BCUL: bias-corrected upper level of 95% confidence interval; IE/TE: ratio of the indirect effect (IE) to the total effect (TE). Results refer to the indirect effect of the proposed mediators investigated separately. Results where the 95% CI does not include zero are considered statistically significant (bold). Given the bootstrapped standard error and *n*, indirect effects effect sizes were computed by transforming the observed coefficients of indirect effects into correlation coefficients (*r*).

the mediator of the relationship between time and reappraisal were similar with a significant *c* path ($b = 3.8$, $SE = .64$, $p < .01$) and *b* path ($b = -.23$, $SE = .07$, $p < .01$). The relationship between time and IU in these models was also significant (*a* path; $b = -3.91$, $SE = .63$, $p < .01$). Both models demonstrated significant indirect effects, with effect sizes (*r*) ranging from .31 to .34. Specifically, IU accounted for 20% of the relationship between time and decentering and 25% of the relationship between time and reappraisal.

Study 1 Summary

These results provide initial support for the hypothesized relationships between emotion regulation skills and IU during ERT. In a combined sample from two open trials of ERT, decentering and reappraisal increased, while the IU decreased over time in treatment. Also as hypothesized, there was an indirect effect of time on IU through emotion regulation skills, such that increases in decentering and reappraisal accounted for a significant proportion of the effect of time on lower IU with medium effect sizes. Indirect effects in the opposite direction (i.e., the effect of time on both decentering and reappraisal through IU) were also significant. Although the size of the indirect effects in both directions were similar, decentering accounted for nearly 45% of the relationship between time and IU, while IU accounted for a smaller proportion (20%) of the relationship between time and decentering. The sizes of the indirect effects were similar when reappraisal was treated both as a mediator and as an outcome, and the proportion of the effect of time on outcome accounted for by the mediator was comparable in both directions.

Although this study provides a useful foundation for understanding the impact of skill building during ERT on IU, the absence of a control group and/or randomized controlled design in Study 1 precludes conclusions about the effects of ERT versus the passage of time or other extraneous variables. This limitation is addressed in Study 2, which sought to demonstrate whether these patterns would emerge in a comparison of individuals randomized to receive ERT versus those in an attention control.

Study 2: Methods

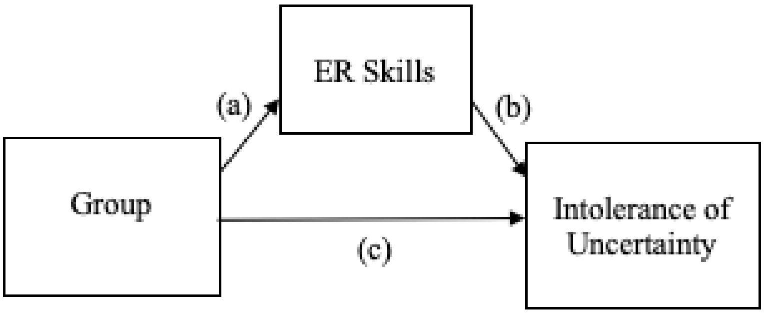
Participants

Participants were enrolled in an RCT of ERT vs. a minimal attention control (MAC) condition (Mennin et al., 2018), which was conducted at two training clinic sites in the Northeastern United States (Site 1 was in Philadelphia, PA, $n = 28$; Site 2 was in New Haven, CT, $n = 25$). Demographics are presented in Table 1 and have been reported elsewhere (Mennin et al., 2018). A total of 28 and 25 individuals were allocated to the ERT and MAC branches, respectively. Inclusion and exclusion criteria were identical to those described in Study 1, including a required diagnosis of GAD as per the ADIS-IV-L (Brown et al., 1994) or SCID-IV (Spitzer et al., 2002). All Study 2 participants were aged 18 and above and were able to speak and understand English.

Procedures

All participants consented to participate in study procedures, which were approved by the IRB at each site. Screening procedures were identical to Study 1. There were no baseline demographic or clinical differences between sites. Therefore, all analyses were conducted on the full aggregate sample (see Mennin et al., 2018). Individuals allocated to ERT received 20 sessions of ERT and were assessed at pre-, mid-, and post-treatment (Times 1 – 3). In the MAC condition, participants were contacted by study therapists for clinical status assessments while they completed all assessment points and awaited ERT following their MAC participation. Additional details regarding randomization and masking procedures can be found in the primary trial paper (Mennin et al., 2018).

Figure 1. Study 2 Hypothesized Indirect Effects



Note. Individuals were randomized to receive either emotion regulation therapy vs. modified attention control. Indirect effects of reappraisal and decentering were measured in separate mediation models.

Measures

The measures utilized in Study 2 were identical to those described in Study 1. Cronbach's alphas for the IUS-12, EQ-D, and ERQ-R ranged from .91 – .94, .80 – .90, and .87 – .82, respectively, indicating good to excellent internal consistency across measures used.

Data Analysis Plan

All descriptive analyses were conducted using SPSS Version 27. Bivariate correlations tested associations among the main study variables at pre-treatment (Time 1) and independent-sample *t*-tests tested for group and site differences in variables of interest at Time 1. To replicate Study 1 findings related to change in IU and emotion regulation skills over time, growth models were run separately for the ERT and MAC conditions. Mixed linear models assessed whether group (ERT vs. MAC) and time interacted to predict IU. Significant interactions were probed using simple slopes. All models used restricted maximum likelihood estimation, and a subject-specific random intercept captured the within-subject correlation. Effect sizes were computed using Cohen's *d* with .20, .50, and .80 indicating small, medium, and large effects, respectively.

Like Study 1, a multilevel mediation approach assessed the indirect effects of reappraisal and decentering on the relationship between group (ERT vs. MAC) and IU (see Figure 1). Mediation models examined the mediating effect of reappraisal and decentering on the relationship between group and IU, accounting for "time" at Level 1 nested within the "individual" at Level 2. Models exploring indirect effects in the opposite direction were also tested (i.e., the mediating effect of IU on the relationship between group and reappraisal and decentering outcomes separately). Indirect effects were tested with 95% bias-corrected confidence intervals and 5,000 bootstrapped samples. No covariates were included in the models, as no significant differences in demographic variables (i.e., age, gender, race) or clinical variables of interest (e.g., IU, decentering, reappraisal) were observed between the groups.

Study 2: Results

Descriptive Statistics and Covariates

Table 1 provides descriptive statistics and frequencies of all control variables in both the ERT and MAC conditions. There were no baseline differences between groups on age ($p = .75$), race ($p = .21$), or gender ($p = .47$). Means and standard deviations of baseline IU, decentering, and reappraisal by group are also presented in Table 1. Growth models revealed that IU decreased ($b = -3.74$, $SE = 1.33$, $p < .01$, $d = .80$), reappraisal increased ($b = 3.52$, $SE = .76$, $p < .001$, $d = 1.34$), and decentering increased ($b = 4.91$, $SE = .82$ $p < .001$, $d = 1.69$) for the ERT condition, but not the MAC (*p*s > .05). Table 2 provides bivariate correlations among reappraisal, decentering, and IU.

Baseline Group and Site Differences

Independent-sample *t*-tests revealed no significant differences between groups (ERT vs. MAC) at pre-treatment (Time 1) on IU (t (51) = -.19, $p = .85$), reappraisal (t (47) = -.46, $p = .65$), or decentering (t (50) = .07, $p = .94$). There were also no differences between sites on IU (t (51) = 0.96, $p = .34$), reappraisal (t (47) = 0.42, $p = .67$), or decentering (t (50) = -.72, $p = .48$) at Time 1.

Group by Time Predicting IU

There was a significant interaction effect of group and time on IU ($b = 4.25$, $SE = 2.13$, $p < .05$, $d = .42$). Simple slopes indicated a significant and greater magnitude of change in IU over time for individuals in the ERT condition ($b = -3.48$, $SE = .87$, $p < .001$) compared to the MAC condition ($b = 1.00$, $SE = .91$,

Table 4. Study 2 Indirect Effects of Proposed Mediators on Primary Outcomes in Both Directions

	B	BSSE	BCLL	BCUL	IE/TE	*r*
IU mediated by						
Decentering	-2.96	1.17	-5.37	-0.80	0.73	0.33
Reappraisal	-1.97	1.12	-4.63	-0.23	0.47	0.24
Decentering mediated by						
IU	1.73	1.12	-0.34	4.14	0.44	0.21
Reappraisal mediated by						
IU	1.45	0.96	-0.23	3.60	0.26	0.21

Note. BSSE: bootstrapped standard error; BCLL: bias-corrected lower level of 95% confidence interval; BCUL: bias-corrected upper level of 95% confidence interval IE/TE: ratio of the indirect effect (IE) to the total effect (TE). Results refer to the indirect effect of the proposed mediators investigated separately. Results where the 95% CI does not include zero are considered statistically significant (bold). Given the bootstrapped standard error and *n*, indirect effects effect sizes were computed by transforming the observed coefficients of indirect effects into correlation coefficients (*r*).

$p = .28$).

Indirect Effects

Within the multi-level mediation framework, the relationship between group (ERT vs. MAC) and IU (*c* path; $b = -4.08$, $SE = 2.60$, $p = .12$) was not significant. However, this does not preclude exploration of whether changes in emotion regulation skills mediated the observed difference between ERT and MAC (O'Rourke & MacKinnon, 2015). The relationship between group and decentering (*a* path; $b = 3.85$, $SE = 1.46$, $p = .01$) was significant, as was the association between increased decentering and lower IU, controlling for group (*b* path; $b = -.77$, $SE = .09$, $p < .01$). There were also significant relationships between group and reappraisal (*a* path; $b = 4.03$, $SE = 1.84$, $p = .03$) and between increased reappraisal and lower IU, controlling for group (*b* path; $b = -.49$, $SE = .09$, $p < .01$). Moreover, both decentering and reappraisal showed significant indirect effects on the relationship between group and IU, with effect sizes (*r*) ranging from .24 to .33 (see Table 4). Decentering accounted for 73% of the relationship between group and IU, while reappraisal accounted for 47% of the relationship.

Again, we also ran separate models testing the inverse relationship, in which IU served as the mediator and decentering and reappraisal were the outcomes. Models testing IU as the mediator of the relationship between group and decentering demonstrated a significant *c* path ($b = 3.85$, $SE = 1.46$, $p = .01$) and *b* path ($b = -.42$, $SE = .05$, $p < .01$). Models testing IU as the mediator of the relationship between group and reappraisal also demonstrated a significant *c* path ($b = 4.03$, $SE = 1.84$, $p = .03$), and *b* path ($b = -.36$, $SE = .06$, $p < .01$). The relationship between group and IU was not significant (*a* path; $b = -4.08$, $SE = 2.6$, $p = .12$). Neither of these models demonstrated significant indirect effects, as indicated by confidence intervals containing zero (see Table 4).

Study 2 Summary

Similar to Study 1, decentering, reappraisal, and IU all changed over time, but only for individuals randomized to receive ERT vs. the control condition. Specifically, as hypothesized, decentering and reappraisal increased, whereas IU decreased during ERT. Further, the results of multilevel mediation in Study 2 replicate those found in Study 1, indicating an indirect effect of group on IU through emotion regulation skills. This significant indirect effect of group on IU through decentering and reappraisal suggests that changes in emotion regulation account for the effect of receiving ERT on reducing IU during treatment. Models testing indirect effects in the opposite direction (i.e., IU as the mediator and emotion regulation skills as outcomes) were not significant. The use of an RCT design in Study 2 further strengthens the notion that these changes are related to treatment rather than the passage of time.

General Discussion

This paper examined the relationships between two emotion regulation skills, decentering and reappraisal, and IU across three treatment studies of ERT for individuals diagnosed with GAD. Study 1 reported aggregate findings from two open trials of ERT, while Study 2 reported findings from an RCT of ERT versus an attention control condition. We predicted that both studies would demonstrate an increase in reappraisal and decentering emotion regulation skills, and a decrease in IU over the course of ERT. We also hypothesized, for Study 1, an indirect effect of time on IU through emotion regulation skills. In Study 2, we additionally hypothesized an interaction between time and group on IU, such that individuals actively receiving ERT would experience a larger decrease in IU over time compared to those in the MAC condition. Finally, we expected to find an indirect effect of increased emotion regulation skills on lower IU for individuals receiving ERT (vs. MAC).

Consistent with hypotheses, results from both studies demonstrated improvements in emotion regulation skills and reductions in IU during ERT. In addition, a group by time interaction in Study 2 indicated a larger decrease in IU over time for individuals receiving ERT than those in the MAC condition. In other words, individuals who received active ERT demonstrated a greater ability to tolerate uncertainty over time than individuals in the control condition. Finally, both studies showed indirect effects of emotion regulation skills on IU. Changes in decentering and reappraisal have been reported in multiple open and randomized controlled trials of ERT (Applebaum et al., 2018; Mennin et al., 2018; Mennin et al., 2015; O'Toole et al., 2019a; Renna et al., 2018) and these emotion regulation skills have been shown to mediate change in GAD severity, worry, disability, and life satisfaction (Mennin et al., 2018; O'Toole et al., 2019b). However, this is the first study investigating IU outcomes during ERT, and the results suggest that not only does IU significantly decrease over time during treatment, but that increases in emotion regulation skills account for a significant proportion of that change.

These findings align with a growing body of literature investigating the impact of CBTs on IU (McEvoy & Erceg-Hurn, 2016). However, research on the necessity of IU-specific interventions to reduce IU for individuals with GAD has been mixed. Specifically, evidence from RCTs indicate the superiority of CBT-IU to reduce IU in comparison to SSRI (Zemestani et al., 2021) and waitlist control conditions (Dugas et al., 2010), whereas CBT-IU may be only marginally superior or inferior to other forms of empirically supported treatments for GAD (e.g., metacognitive therapy [MCT], applied relaxation) (Dugas et al., 2010; van der Heiden et al., 2012). Given inconsistencies in the literature, it is important to understand the impact of non-IU-specific cognitive behavioral interventions on reducing IU during treatment. ERT is one such form of treatment that appears to shift this outcome.

ER skill-building (e.g., decentering, reappraisal) is also increasingly ubiquitous to CBT (Fresco & Mennin, 2019), and thus these skills may be useful treatment targets for reducing IU in GAD. Indeed, our findings suggest that when individuals improve their metacognitive capacities (e.g., decentering, reappraisal), they are better able to tolerate uncertainty. Speculatively, these findings may also help explain why MCT produced better results than IU-specific treatment in one study (van der Heiden et al., 2012), since MCT emphasizes both thought restructuring and introduces alternative strategies for coping with triggers (e.g., letting go of thoughts). Additional studies comparing the impact of various cognitive behavioral interventions to reduce IU would be needed to explore these questions empirically.

The presence of bidirectional indirect effects in Study 1 but not Study 2 is also worth examining. Specifically, Study 1 found that increases in emotion regulation skills mediated decreases in IU and vice versa, whereas the effect of group on emotion regulation skills through IU was not significant in Study 2. The presence of bidirectional effects in Study 1 precludes the establishment of temporal precedence, a necessity to establish causality in a mediation model (Lee et al., 2021). However, when we re-examined these effects in an RCT design (Study 2) as per mediation guidelines (Kazdin, 2007; Smits et al., 2012), there were no longer significant indirect effects of group on emotion regulation skills through IU. It is possible that the indirect effects observed in Study 1 were an artifact of the open trial design, and findings from reverse models (i.e., switching the mediator and the outcome) in intervention studies assessing temporal precedence for IU are inconsistent in the literature (Rosser, 2019). It will be important to further tease apart potential bidirectional effects of emotion regulation skills and IU in the context of future intervention research.

Thus, with some qualifications (i.e., bidirectional effects from open trial design in Study 1), our findings suggest that increased emotion regulation skills mediate reductions in IU during ERT, but not vice versa. Farach and colleagues (2008) found that fear and avoidance of emotions, but not IU, mediated the relationships between analogue GAD and negative psychological outcomes 12-months after the 9/11 attacks in New York City. One plausible explanation is that while IU is the central, core fear underlying GAD and may be a better indicator of generalized anxiety symptomatology than worry (Carleton, 2016a, 2016b; Jensen et al., 2016), emotion regulation skills are malleable and thus more likely to mediate change. If this were the case, we might expect IU to function similarly to trait neuroticism, an associated construct (Yang et al., 2015) that may be defined as a characteristic tendency for heightened sensitivity to internally generated emotional cues (Barlow et al., 2014; Mennin & Fresco, 2015). Traditionally, neuroticism has been considered more stable and inflexible than symptoms of psychopathology (e.g., mood and anxiety disorders), and findings on the impact of CBTs to reduce neuroticism have been mixed (see Sauer-Zavala et al., 2021). Interestingly, a recent RCT for anxiety comparing a neuroticism-focused version of the Unified Protocol (UP) to symptom-focused CBT found significantly lower neuroticism in the UP group after controlling for symptom changes; the authors argue that these robust findings may be due to the direct targeting of neuroticism in the treatment (Sauer-Zavala et al., 2021). If IU functions similarly to neuroticism, it would be unsurprising that IU appears less malleable and targetable as a mediator in ERT given that ERT does not specifically target IU the way an IU-specific treatment would.

Moreover, the IU findings from the present studies of ERT may be interpreted in support of an emotion regulation model of distress disorders, which views emotions as functionally linked to motivations that mobilize our attention to both threats and rewards (Mennin & Fresco, 2015). According to this model, the “reward system” signals motivations towards appetitive stimuli and to minimize loss of these stimuli, and the “security system” signals motivations towards safety and away from threat. GAD, which has been described as the “unsuccessful search for safety” (Woody & Rachman, 1994), may thus reflect a motivational imbalance in which an individual experiences heightened sensitivity to safety, often overriding reward (see Mennin & Fresco, 2015). Though conjecture, it is plausible that measures of IU capture motivational imbalance (e.g., overactive safety system, underactive reward system) at the core of GAD, and thus may be examined as a trait moderator of the effects of emotion regulation skill-building in treatment (Baron & Kenny, 1986). In support of this perspective, Morriss and colleagues (2022) recently found that uncertainty not only increased the intensity of negative emotion states, but also dampened the intensity of positive emotional states; they also reported that individuals high in IU found uncertainty aversive even when there was only the potential for positive outcomes (Morriss et al., 2022). Further research is needed to substantiate or address alternative models integrating IU and emotion regulation constructs to form a coherent perspective.

However, there has also been research in support of IU as a malleable treatment target based on different patterns of mediation findings. For instance, Bomyea et al. (2015) found that while IU mediated lower worry over time for individuals with GAD during CBT, preceding worry did not mediate change in IU over time. However, this study relied on an open trial design, which limits the interpretation of the findings (Bomyea et al., 2015). In addition, IU has been described as a targetable mechanism of clinical change in the treatment of OCD (Grayson, 2010) and there is evidence that exposure and response prevention, the first-line treatment for OCD, works by disconfirming distorted cognitions through exposures, including beliefs pertaining to IU (see Hezel & McNally, 2016). However, there is also evidence for alternative mechanisms of action in the treatment of OCD from other perspectives (e.g., behavioral, emotion processing) (see Hezel & Simpson, 2019 for review; Su et al., 2016). Research should continue to examine the nature of IU in GAD-specific treatment and transdiagnostically, particularly in relation to different types of emotion regulation strategies (Sahib et al., 2023).

The results of the current study should be viewed in light of some limitations. First, these analyses used a product-of-coefficients method, which is a correlational approach that cannot address questions of causality in the relationship. Second, while the primary inclusion criteria in both Study 1 and Study 2 was a DSM-IV diagnosis of GAD, many participants in both trials met DSM-IV criteria for additional mental disorders (see primary trial papers; Mennin et al., 2015; Mennin et al., 2018; Renna et al., 2018). Thus, it is possible that the observed effects are due to co-occurring diagnoses rather than, or in addition to, the presence of GAD. Moreover, given the use of trait measures to assess emotion regulation, it is possible that nuances relating to the relationship between IU and ER skills use over time were not fully captured. Broadly, more work is needed to understand the temporal dynamics of emotion regulation in relation to IU and other trait-like constructs (e.g., emotional variability; Kuppens & Verduyn, 2015). Finally, most individuals who participated in ERT across these studies identified as white, and thus the results should be replicated in a less homogenous sample that is representative of the range of individuals who struggle with GAD (Budhwani et al., 2015).

Despite these limitations, the current study sheds light on the impact of skill-building during ERT on IU and highlights many interesting avenues for future investigation. First, it is possible that specific dimensions of IU drive the relationship between the ability to tolerate uncertainty and emotion regulation skills during treatment for individuals with GAD. For example, it may be that prospective IU, which represents cognitive appraisals of threat related to future uncertainty, is more strongly related to GAD than inhibitory IU, which represents behavioral inhibition related to uncertainty (Shihata et al., 2016). Evidence for diagnosis-specific dimensions of IU is mixed (Jensen et al., 2016; Penney et al., 2020), and future research should continue to examine the discriminant validity of prospective vs. inhibitory IU, particularly in relation to proposed mechanisms of action in treatment for different affective disorders.

Relatedly, it will be important to examine IU outcomes for different types of CBTs. Despite commonalities across therapies regarding emotion regulation, treatments vary in their approach to skill-building, including the sequence in which emotion regulation skills are taught and the "dose" of each skill (e.g., number of sessions). Future research should examine what impact (if any) these differences have on the relationship between emotion regulation and IU over time during treatment. Furthermore, the type of skills taught varies across therapies and it would be interesting to explore changes in other emotion regulation skills, including attentional strategies (e.g., acceptance; Hayes et al., 1999; Kohl et al., 2012), in relation to IU during treatment (Lindsay & Creswell, 2019; Malivoire, 2020). These areas for future research align with emphases in the literature on improving psychological flexibility and adaptive abilities during treatment, regardless of whether improved flexibility is explicitly stated as a research aim or included implicitly in treatment through other means (Kashdan & Rottenberg, 2010).

In sum, this was the first study to examine IU across ERT and adds to a growing body of literature, highlighting the utility of non-IU-specific interventions to help individuals tolerate uncertainty. Findings emphasize the importance of emotion regulation skill-building during treatment and present opportunities for future research exploring the wide-range of psychological benefits that emotion regulation skill cultivation can have on individuals with GAD and associated disorders. Exploring the impact of emotion regulation skills on decreasing IU could lead to improvements in treating GAD across a range of therapeutic protocols.

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Conflict of Interest

The authors declare that they have no known conflicts of interest to disclose.

Ethical approval

This study was approved by the institutional review board at all study sites.

Data Availability

The data are not openly availably due to absence of specific consent by study participants for this purpose.

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