Within Person Associations of Thought Uncontrollability and Negative Valence with Anxiety Symptoms: A Daily Diary Investigation

by

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Background: Perseverative thought (PT) is a cognitive process involving marked repetitive and uncontrollable mental activity centered on a particular theme. Recently, research investigating the characteristics of PT that vary within person has identified thought uncontrollability and negative valence as characteristics of PT that are strongly related to anxiety-related disorders at the between-person level. Despite findings that thought uncontrollability and negative valence are dissociable dimensional features of PT, no studies have looked at their concurrent or prospective within-person associations with anxiety. This research gap is important to address because major psychological theories of PT propose a specific role for uncontrollability, above and beyond negative valence, in contributing to the adverse effects of PT. Thus, this study uses a prospective longitudinal daily diary design to investigate the independent and incremental within-person associations of thought uncontrollability and negative valence with anxiety symptoms.

Method: Prospective daily-diary measures of thought uncontrollability (hard-to-stop, intrusive, repetitive), negative valence (happy [reversed scored], nervous), and anxiety symptoms were completed by 200 undergraduate students for 15 days. Six multilevel models were conducted to examine the within person associations of thought uncontrollability and negative valence with anxiety symptoms. Two sensitivity analyses examined whether greater thought uncontrollability was differentially associated with specific facets of anxiety (anxious arousal and anxious apprehension).

Results: Uncontrollability and negative valence were positively associated with same-day anxiety symptoms. Furthermore, uncontrollability was incrementally positively associated with same-day anxiety symptoms beyond negative valence. However, greater uncontrollability did not predict next-day anxiety symptoms. Unexpectedly, greater uncontrollability was related to both higher anxious arousal and higher anxious apprehension within person.

Conclusion: This study suggests that negative valence and uncontrollability are transdiagnostic characteristics of PT that relate to anxiety, but may not prospectively predict anxiety, within person. Future research should directly explore the temporal specificity of how these dimensions of PT relate to anxiety over time.

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1.0 Introduction

Perseverative thought (PT) refers to a style of thinking that is marked by repetitive and uncontrollable mental activity (Hallion et al., 2022). Historically, the operationalization of PT has followed a disorder-specific model, where thought types are grouped into distinct categories (e.g., worry; rumination; obsessions) and studied in the context of a specific disorder. For instance, the two most studied forms of PT, worry and rumination, have been largely studied within the context of generalized anxiety disorder (GAD; Borkovec, 1994) and depression (Nolen-Hoeksema et al., 2008), respectively. Numerous studies indicate that these forms of PT play a major role in the development, maintenance, and recurrence of emotional disorders such as anxiety disorders (Arditte et al., 2016; Borkovec, 1994), mood disorders (Nolen-Hoeksema et al., 2008), obsessive-compulsive disorder (OCD; Rachman, 1997; Salkovskis et al., 1998), and post-traumatic stress disorder (PTSD; Ehlers & Steil, 1995). More recently, the repetitiveness and uncontrollability of these thought types have been identified as the central characteristics that account for the strong relationship between PT and emotional disorders (Ehring et al., 2011; Hallion et al., 2022). These findings provide further insights into how we understand and conceptualize PT.

Recent advances in quantitative modeling have made it possible to better understand the transdiagnostic phenomena of PT. For instance, the increased use of latent-variable modeling techniques, in which the observed associations among measured variables can be thought of as consequences of one or more latent (unobserved) factors (Curran & Hussong, 2003), has increasingly been applied to study the structure of PT (Ehring et al., 2011; Hallion et al., 2022). This shift from a categorical (thought types) to a dimensional (latent characteristics) approach is consistent with a broader emergence of dimensional modeling in psychopathology research (Kotov

et al., 2017; Wright et al., 2013). These principles have been extended to enable the identification of the shared (transdiagnostic) latent characteristics of PT, including characteristics that vary within person. For example, one recent study applied multi-level modeling to examine the latent structure of PT within person (Hallion et al., 2022). That study concluded that PT is better organized and more accurately organized using latent dimensions than latent categories (thought types) in terms of statistical fit, interpretability, and replicability.

Research into the specific underlying dimensions has found consistent support for an uncontrollability dimension, which reflects thoughts that are intrusive, repetitive, and difficult to dismiss (Ehring et al., 2011; Hallion et al., 2022). A recent multi-level modeling study showed that uncontrollability of thought was strongly associated with transdiagnostic PT severity (r = .52) and was the strongest predictor across outcomes of anxiety and depression (Hallion et al., 2022). Valence, which refers to the positive or negative characteristic of an emotional experience, has been shown to be another important dimension of PT, both when considered in the context of specific thought types (rumination; Siegle et al., 2004), and when examined transdiagnostically (Hallion et al., 2022; Segerstrom et al., 2003).

1.1 Perseverative thought: Uncontrollable thoughts in anxiety

Several leading theoretical models of anxiety emphasize uncontrollability as a critical feature of PT. For instance, the cognitive avoidance theory of worry (Borkovec, 1994; Borkovec et al., 2004), proposes that worry is "negatively affect-laden and relatively uncontrollable" and that uncontrollable worrisome thoughts are primarily used to dampen anxious arousal in response to perceived future threats. The theory further suggests that this inhibition of anxious arousal

prevents the emotional processing of fear, and thus prolongs uncontrollable worrisome thoughts (Borkovec, 1994). The cognitive avoidance theory of worry argument is consistent with research evidence from the neurobiological and basic cognitive science literature, which distinguishes anxiety and fear as two separate emotional constructs (LeDoux & Pine, 2016; Sylvers et al., 2011). Uncontrollable worry is proposed to relate to these two emotional constructs (i.e., fear and anxiety) differently. Whereas anxiety is conceptualized as prolonged hypervigilance and hyperarousal in response to a potential threat, fear is characterized by avoidant behavior of fearful stimuli (Sylvers et al., 2011). The cognitive avoidance theory of worry suggests that uncontrollable worry may initially contribute to a reduction in autonomic arousal (i.e., fear), but heightens anxiety symptoms over time by maintaining threat associations (Borkovec et al., 2004).

Additionally, uncontrollable worry is recognized as a central diagnostic feature of GAD (American Psychiatric Association, 2013). Since worry uncontrollability has been implicated in both the cognitive avoidance theory of worry and is a diagnostic feature of GAD, researchers have prioritized understanding the role of uncontrollable worry in the development and maintenance of GAD (Borkovec, 1994; Hallion & Ruscio, 2013). The cognitive avoidance theory has been mainly supported by cross-sectional and experimental studies, which have shown that the uncontrollability of thought distinguishes individuals with high and low trait worry (Borkovec et al., 1983) and individuals with and without GAD (Borkovec, 1994; Craske et al., 1989). Another study that examined uncontrollable worry among GAD and non-GAD high worriers using an experimental worry induction showed that high worriers with GAD experienced less control over negative intrusive thoughts compared to high worriers without GAD (Ruscio & Borkovec, 2004). In one study that used between-person structural equational modeling to examine the constructs of PT (i.e., worry, rumination), uncontrollability explained a large percent of the variance in the

relationship between PT and other symptoms of emotional disorders such as anxiety and depression (Topper et al., 2014). These findings are broadly consistent with the cognitive avoidance theory, which implicates thought uncontrollability in the etiology of anxiety disorders.

Another prevailing theoretical model of anxiety that highlights uncontrollability as an important feature of PT is the metacognitive model of worry (Wells, 1995). The metacognitive theory proposes that individuals with GAD hold negative metacognitive beliefs about their worry, i.e., worry is uncontrollable, and once these beliefs are activated, they contribute to the transition, development, and maintenance of anxiety (Wells & Carter, 1999). Cross-sectional studies have mainly supported the metacognitive theory; specifically, they show that people who experience pathological worry, GAD, and other anxiety symptoms appraise their worry as more pervasive and less controllable compared to individuals with no diagnoses (Wells, 2006). For instance, negative beliefs about control over worry have been found to discriminate between individuals with GAD from healthy controls (Cartwright-Hatton & Wells, 1997), and normal and pathological worry (Hirsch et al., 2013; Turner et al., 1992). In another study that directly compared uncontrollability and excessiveness of worry in a large community sample, beliefs that worry was uncontrollable explained additional variance in GAD severity, comorbid disorder amount and severity, as well as treatment use after controlling for the excessiveness of worry (Hallion & Ruscio, 2013). Lastly, in one longitudinal study, beliefs that thoughts were uncontrollable predicted daily worry above and beyond trait worry (Thielsch et al., 2015). Overall, these findings suggest that uncontrollability may potentially explain the well-documented relationship between PT and anxiety symptoms.

Psychometric studies provide further support for the role of uncontrollability in PT. Specifically, factor analysis has been used to identify uncontrollability as a latent dimension of PT. For example, the Perseverative Thinking Questionnaire (Ehring et al., 2011) was developed to

assess trait-like PT independent of thought content and valence. Factor analysis revealed a higher-order factor that reflected thought uncontrollability, as well as three lower-order factors that comprised the core characteristics of uncontrollability such as repetitiveness, intrusiveness, and difficulty to dismiss (Ehring et al., 2011). In a similar study, the Perseverative Cognition Questionnaire was developed to measure trait-level dimensions of maladaptive perseverative cognition irrespective of thought content (Szkodny & Newman, 2019). Factor analysis revealed that uncontrollability was one of the core dimensions of PT and increased uncontrollable thinking was associated with symptoms of anxiety, depression, and OCD over two weeks (Szkodny & Newman, 2019). More recently, in a study using multilevel modeling that examined both between- and within-person relationships, the findings showed that uncontrollability emerged as the central feature of PT within-person, and accounted for significant variance in the relationship between thought characteristics and anxiety and depression symptoms between-person even after controlling for valence (Hallion et al., 2022). In accordance with Ehring et al. (2011), this study provided further support that repetitiveness, intrusiveness, and difficulty to dismiss were the core characteristics of uncontrollability (Hallion et al., 2022). Taken together, these findings highlight that thought uncontrollability may be associated with greater anxiety symptoms.

1.2 Perseverative thought: Negative valenced thoughts in anxiety

Another important facet of PT lies in its valence, which describes the extent to which an emotional response is along a continuum from negative to positive (Barrett & Russell, 1999; Russell, 2003). For instance, happiness is typically characterized by positively-valenced thoughts, whereas sadness is typically characterized by negatively-valenced thoughts. An example of a

positively-valenced thought is an individual repetitively daydreaming about a crush on someone; whereas an example of a negatively-valenced thought is a student worrying about an upcoming exam. Most types of PT (e.g., worry; rumination; obsessions) are characterized by negative valence. For instance, depressive rumination is characterized by negatively-valenced thoughts about emotional materials (Nolen-Hoeksema et al., 2008); worry can be defined as negatively valenced thoughts about a real or a potential future problem (Borkovec et al., 2004), and obsessions are characterized by excessive negative-valenced cognitions that are ego-dystonic, where the individual perceives them as inappropriate or harmful (Armstrong et al., 2011).

Cognitive theories have long suggested that the valence of a thought is an essential determinant of psychological functioning (Beck, 1967). For instance, positively valenced thoughts are at the core of constructs such as self-esteem, mastery, and optimism that contribute to better adjustment and psychological functioning (Taylor & Brown, 1988). In a detailed review of research on PT, it was suggested that the valence of the thoughts contributes to the adaptiveness versus non-adaptiveness of PT (Watkins, 2008). Owing to this theoretical debate on valence, there has been extensive literature investigating valence as a dimension of PT. Similar to uncontrollability, psychometric studies support valence as an independent underlying dimension. For example, one study applied factor analysis to examine similarities and differences in rumination using six different trait measures of rumination with diverse populations such as undergraduates, depressed adults, and healthy adult populations (Siegle et al., 2004). The results revealed that across the different self-report assessments measuring rumination, valence was a central dimensional feature (Siegle et al., 2004). In another study, researchers classified repetitive thought at the level of the thought by asking student participants to rate “something that has been on your mind lately” on a variety of unidimensional features (e.g., valence; Segerstrom et al.,

2003). The descriptions were subsequently given to a second group of participants who were instructed to sort these thoughts into groups based on their similarities. The researchers utilized multidimensional scaling across the two samples and the results revealed a valence dimension of PT, which included negative content on one pole and positive content on the other pole (Segerstrom et al., 2003). The results further showed that valence was robust and appeared across between-person analyses of unstructured state PT descriptions and within-person analyses of trait PT questionnaires (Segerstrom et al., 2003). More recently, a study that used multilevel exploratory factor analysis to examine the dimensionality of PT identified valence as one of five major dimensions of PT (Hallion et al., 2022) with strong associations with trait measures of PT as well as anxiety and depression (Hallion et al., 2022).

One major argument that has been put forward by cognitive theorists is that the negative valence of thoughts helps to explain the relationship between perseverative thinking and a host of negative consequences such as anxiety (Segerstrom et al., 2003; Watkins, 2008). In cross-sectional and experimental studies, valence is strongly linked to anxiety symptoms. For example, one study (Segerstrom et al., 2003) examined the relationship between dimensions of PT such as valence (valence was rated from 1 “very positive” to 5 “very negative”) and mental health outcomes among women at high risk for breast cancer. The results showed that negative valence was associated with greater negativity (e.g., sad, unhappy feelings), worse psychological functioning, and greater anxiety symptoms. On the other hand, when thoughts were more positively valenced, individuals reported greater ratings of positive affect and well-being. Furthermore, in a large meta-analysis of 226 studies on the relationship between self-focused attention and psychological symptoms, attention to negatively valenced thoughts about the self was linked to higher levels of negative affect as well as depression and anxiety, while attention to positively valence thoughts about the

self was related to lower levels of negative affect (Mor & Winquist, 2002). Overall, these findings demonstrate that greater negative valence may be associated with higher anxiety symptoms.

1.3 Knowledge Gaps Addressed

Despite the recent proliferation of research highlighting that valence and uncontrollability are core dimensional features of PT (Ehring & Watkins, 2008; Hallion et al., 2022; Szkodny & Newman, 2019), there remain important gaps in the literature. To date, no studies have looked at the within-person associations of thought uncontrollability and valence with anxiety. This gap in the literature remains important to address because most psychological theories are within-person processes (Curran & Bauer, 2011). For instance, the underlying theories of PT such as the cognitive avoidance theory of worry and the metacognitive theory of worry (Borkovec, 1994; Wells, 1995) suggest that uncontrollable (worrisome) thoughts will happen *within* a given individual.

By contrast, the majority of previous studies on PT have employed cross-sectional designs. Cross-sectional studies or between-person designs are limited to examining inter-individual differences (e.g., are uncontrollable thoughts associated with higher anxiety symptoms across individuals?). Between-person designs treat uncontrollability as a trait-like characteristic, something that differs between people. On the other hand, within-person designs (i.e., intra-individual differences) address mechanisms of action *within* a given individual (e.g., does an individual experience more anxiety symptoms following higher thought uncontrollability?).

Only two studies thus far (Hallion et al., 2022; Segerstrom et al., 2003) have investigated the associations between these latent dimensions of PT (i.e., uncontrollability, valence) and anxiety symptoms. These studies were particularly novel because they modeled the classification of PT at

the level of the thought (within-person), which controlled for person-level characteristics. However, these studies still approached the associations of uncontrollability and valence with anxiety at the between-person level. When uncontrollability and valence are assessed between persons, it is difficult to know whether shared person-level variance represents specific characteristics of the thoughts or person-level characteristics. This is a limitation because individuals tend to endorse varying "types" of thoughts and these thoughts tend to co-vary (McEvoy et al., 2013). For instance, individuals who tend to experience higher rates of negative valence thoughts may also experience higher rates of difficulty concentrating (between-person effect). Nonetheless, this does not mean that at the within-person level, experiencing a negatively-valenced thought would directly contribute to difficulties concentrating, once person-level characteristics are controlled. Also, we cannot assume that findings at the between-person level are generalizable to the within-person level. To provide one striking and relevant example, one study illustrated that at the within-person level, lack of control over thoughts was associated with increases in problem-solving behaviors; however, this association was not found at the between-person level (Segerstrom et al., 2016). This finding demonstrated that the process of aggregating estimates of our variables of interests (i.e., between-person) may not be useful in drawing inferences to within-person estimates.

Intensive longitudinal design (Hoffman & Stawski, 2009), which is the repeated sampling of variables longitudinally (e.g., momentarily, daily, weekly) allows for the examination of within-person processes. Daily diary designs are a type of intensive longitudinal method that aims to capture people's experiences closer to the time they occur in their natural environment (Bolger et al., 2003). A benefit of using a daily diary design is that it limits retrospective reports of symptoms. Although retrospective reports of PT do have utility for capturing the influence of PT on emotional

disorders, they can be especially prone to recall errors and biases (Mineka et al., 2003). For example, a study showed that momentary assessment of ruminative thoughts predicted higher cortisol levels both in depressed and healthy participants in daily life, whereas trait rumination and retrospectively assessed depressive symptoms failed to predict this effect (Huffziger et al., 2013). The daily diary method is a more ecologically valid method to assess how these thoughts unfold in daily life by limiting retrospective bias, thereby increasing the generalizability of the findings.

Since daily diary method involves intensive longitudinal data collection of assessments over time (Bolger et al., 2003), it can help us draw conclusions about the temporal relationship of thought uncontrollability and negative valence with anxiety. For instance, we can better investigate the metacognitive model of worry by examining how greater thought uncontrollability within a person is associated with higher anxiety symptoms within that same person. Additionally, we can examine tenants of the cognitive avoidance theory of worry; specifically, by studying whether more severe thought uncontrollability within person is differentially associated with anxious arousal (which worry is proposed to suppress) versus anxious apprehension (which worry is proposed to increase) ((Borkovec, 1994). Thus, a daily diary study can capture the variability of thought uncontrollability, negative valence, and anxiety within person over time.

1.4 Current Study

This present study addresses the above-mentioned limitations by using a prospective daily diary design to investigate whether thought uncontrollability and negative valence are incrementally related to anxiety symptoms within-person, and whether uncontrollability dampens anxious arousal and heightens anxious apprehension within-person. First, I aim to examine the

within-person associations of thought uncontrollability and negative valence with same-day anxiety symptoms. Second, I am to examine whether thought uncontrollability is related to same-day anxiety symptoms above and beyond negative valence. Third, I aim to examine the within-person associations of thought uncontrollability and negative valence with next-day anxiety symptoms. Fourth, I aim to dissociate the specific contribution of thought uncontrollability to next-day anxiety symptoms above and beyond the variance explained by same-day anxiety and negative valence. Lastly, to examine the potential differences between fear and anxiety, I aim to conduct sensitivity analyses treating stress (apprehension) and fear (arousal) separately, to investigate the within-person associations of thought uncontrollability with arousal and apprehension.

Hypothesis 1: Greater thought uncontrollability will be associated with more severe anxiety symptoms on the same-day within person.

Hypothesis 2: Greater negative valence will be associated with more severe same-day anxiety symptoms within person.

Hypothesis 3: Greater thought uncontrollability will be associated with more severe same-day anxiety symptoms above and beyond negative valence.

Hypothesis 4: Greater thought uncontrollability will be associated with more severe next-day anxiety symptoms within person.

Hypothesis 5: Greater thought uncontrollability will be associated with more severe next-day anxiety after controlling for same-day anxiety symptoms within person.

Hypothesis 6: Greater thought uncontrollability will predict more severe next-day anxiety symptoms within person after controlling for same-day anxiety symptoms and negative valence.

Taken together, the latter finding would demonstrate whether thought uncontrollability accounts for more variance in next-day anxiety than negative valence and same-day anxiety.

Hypotheses for Sensitivity Analyses

Hypothesis 7: Greater thought uncontrollability will be associated with lower anxious arousal within person.

Hypothesis 8: Greater thought uncontrollability will be associated with higher anxious apprehension within person.

2.0 Method

2.1 Participants

200 participants were recruited between February and March 2021 from introductory psychology courses at the University of Pittsburgh into a daily diary study, in which they answered end-of-day questionnaires about their mental health for 15 days. All participants gave informed consent to participate and this study was approved by the University of Pittsburgh IRB committee.

Consistent with previous studies (Hallion et al., 2020), we excluded participants who were univariate outliers (≥ 3 SD above or below the sample mean) on thought uncontrollability, negative valence, and symptom scores. Seven participants were removed due to outliers. The final analytic sample was comprised of 193 participants (63% women, 2.6% non-binary, age M = 20 (SD = 3). The sample was predominantly White (73% White, 16% Asian or Asian American, 6% Black or African American, 4% Biracial or Multi-racial, & 1% Other); 6% of the sample identified as Hispanic or Latinx.

2.2 Procedures

Study orientation and participation were conducted entirely online without direct contact with study staff. Participants completed all assessments using Qualtrics, which is a password-protected and encrypted data collection system (Qualtrics, Provo, UT). Participants completed an extensive battery of trait self-report questionnaires, including the PT assessment at baseline (Day

1) and at the end of the first (Day 8), and second (Day 15) study weeks. Links to the daily diary assessments were sent to participants via email and completed on the participants' laptops, tablets, or smartphones. Participants were asked to complete the survey before 9:00 p.m. each day. The daily diary, baseline (Day 1), Day 8, and Day 15 administrations resulted in approximately 15 total administrations of the PT assessment over the course of the study.

2.3 Measures

2.3.1 Self-reported measure of perseverative thought

Perseverative thought. Trait PT was measured using the Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011). Participants are asked to rate their process of thinking on a scale from 0 (never) to 4 (almost always). Sample items include, "the same thoughts keep going through my mind again and again" and "my thought prevents me from focusing on other things." The PTQ is a validated and widely used measure of transdiagnostic PT (Ehring et al., 2011) and has demonstrated strong internal consistency, good test-retest reliability, and convergent validity (Ehring et al., 2011). Cronbach's alpha in the current sample was 0.95 at baseline.

Worry. The Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990) was used to measure trait worry and the uncontrollable characteristics of pathological worry. The 16-item Likert scale consists of scores ranging from 1 ("not at all typical of me) to 5 ("very typical of me"). The PSWQ has also demonstrated good convergent and discriminant validity (Brown et al., 1992) and high test-retest reliability from periods of 8 to 10 weeks (Meyer et al., 1990). Cronbach's alpha in the current sample was 0.77 at baseline.

2.3.2 Daily diary measures

Thought features

Participants were asked to provide an open-text description of "a thought that has been on your mind a lot today." Participants then rated that thought on a variety of features (below). Items were adapted from (Hallion et al., 2022) and show good psychometric properties in preliminary validation studies (Hallion, Olino, et al., in prep). Thought ratings were made on 9-point Likert-type rating scales with anchors at 1 (not at all); 3 (a little / mildly); 5 (somewhat / moderately); 7 (very much / severely); and 9 (extremely).

Uncontrollability. Uncontrollability was assessed using three items: 1) difficult to dismiss (hard to stop); 2) intrusive (comes into my mind when I don't want it there); and 3) repetitive (repeats over and over again). Cronbach's alpha in the present sample was 0.85 at baseline.

Valence. Valence was assessed using two items: 1) happy (reverse-scored) and 2) nervous. Cronbach's alpha in the present sample was 0.46 at baseline.

Anxiety measures

Anxiety. The Depression Anxiety and Stress Scales short form (DASS-21; Lovibond & Lovibond, 1995) is a 21-item self-report questionnaire that assesses depression symptoms, fear symptoms such as anxious arousal, and symptoms of stress such as anxious apprehension. The fear subscale measures acute responses to fear as well as subjective and somatic symptoms of anxiety. The stress subscale measures symptoms such as difficulty in relaxing, nervous tension, irritability, overreaction to stressful events, and impatience (Lovibond & Lovibond, 1995). Participants were asked to read each statement carefully and indicate how much each statement applied to them over the past day. The responses were rated on a scale from 0 ("did not apply to me at all") to 3 ("applied to me very much / most of the time"). The DASS-21 has been found to have strong internal

consistency and test re-test reliability (Brown et al., 1997; Henry & Crawford, 2005). Research studies have revealed that the fear and stress subscales are highly correlated (Antony et al., 1998; Wang et al., 2016). Given the high correlation between the DASS anxiety and stress subscale, it has been recommended that a combined fear-stress subscale composite is a better fit to measure anxiety in undergraduate and community samples (Daza et al., 2002; Tully et al., 2009). Cronbach's alpha for anxiety was 0.86 at baseline.

Arousal. The fear subscale from the DASS-21 questionnaire (Lovibond & Lovibond, 1995) was used to measure arousal. Sample items include: "I felt I was close to panic", "I experienced breathing difficulty (e.g., excessively rapid breathing)", and "I felt scared without any good reason." Cronbach's alpha for the fear subscale was 0.78 at baseline.

Apprehension. The stress subscale from the DASS-21 questionnaire (Lovibond & Lovibond, 1995) was used to measure apprehension. Sample items include: "I found it hard to wind down", "I tended to overreact to situations", and "I found it difficult to relax." Cronbach's alpha for the stress subscale was 0.80 at baseline.

2.4 Analytical Plan

The analyses for our main hypotheses were conducted using R Studio (Team, 2013). We ran multilevel modeling (MLM; Bagiella et al., 2000) using the *lme4* package (Bates et al., 2015) to examine our primary hypotheses. MLM holds several advantages over traditional data analysis approaches. First, MLM is robust in handling cases with missing data, so missing data are not removed from data analyses (Curran & Bauer, 2011). Second, MLM involves a model for error variance, which can lead to more efficient estimates and powerful tests (Bagiella et al., 2000).

Third, MLM is more flexible, allowing one to model the dependence of outcomes on both fixed and time-varying predictors (Curran & Bauer, 2011). All models were performed using full maximum likelihood estimation, fixed effects, random intercepts, and random slopes. In the case where the models with random slopes did not converge, we excluded the random slopes and only included the random intercept in the MLM analysis.

Thought uncontrollability items were calculated by summing their corresponding dimensional items (i.e., hard-to-stop, repetitive, and intrusive). For the negative valence items, we first reverse-coded happy, and then summed nervous and the reverse-coded happy item to create a composite score for negative valence. The arousal and apprehension scores were calculated by adding the corresponding items from the DASS fear and DASS stress subscale and multiplying by 2, respectively. Scores for anxiety were calculated by adding the scores from the DASS arousal and apprehension subscales and then multiplying by 2 (Lovibond & Lovibond, 1995);

Afterwards, we inspected missing data mechanisms using the *mice* package (Buuren & Groothuis-Oudshoorn, 2011). Our results indicated that our data was not missing completely at random (MCAR) using the Little's MCAR test ($p < .0001$) (Little, 1988). Given this finding, we used multiple imputations to handle missing data. Multiple imputation is considered to be one of the most robust methods for handling missing data in longitudinal designs (Lüdtke et al., 2017). It is advantageous because it helps to reduce bias in parameter estimates and standard errors while maintaining the original relationships among variables (Van Ginkel et al., 2020). We performed multiple imputations ($m = 5$ imputed data sets) to impute values for all missing data using the *mice* package (Buuren & Groothuis-Oudshoorn, 2011).

We ran separate MLM with the original dataset (i.e., non-imputed dataset) and the imputed dataset and compared the results for the fixed effects; there were no differences in the MLM results

for the fixed effects in the two datasets. Since running multiple imputations with the *mice* package does not output the values for the random effects (Buuren & Groothuis-Oudshoorn, 2011), we present findings from the original dataset (i.e., non-imputed dataset) for clarity and ease in interpretation. Then, we used the sjPlot package (Lüdecke, 2018) to calculate the intra-class correlation (ICC) of our models. Lastly, we report both the marginal R^2 (variance explained by only the fixed effects) and the conditional R^2 (variance explained by the fixed effects and random effects) of all our models (Nakagawa & Schielzeth, 2013). The MLM equations for all the hypotheses can be found in Appendix A.

Since this study was a secondary data analysis, a post hoc power analysis was conducted using the *mixedPower* R package (Kumle et al., 2018), which uses the data to simulate new data of a sample of identical size as that used to fit the model parameters 1000 times (Kumle et al., 2018). The smallest effect in the study (within-person association of thought uncontrollability and same-day anxiety symptoms) was chosen for the within-subject factor in the mixed effect model. Through post hoc power analysis, it was computed that with 200 participants, we had 99% power to detect an effect of 0.8 or greater.

3.0 Results

3.1 Preliminary Analyses

At baseline, participants reported a moderate level of trait worry (M = 52.4) and trait perseverative thought (M = 31.2). See Table 1 for sample characteristics. Further descriptive information for the daily diary measures can be found in Table 2. The ICC of our models indicates that 62 – 66% of same-day and next-day anxiety can be attributed to person-to-person variation (between person), whereas 34 - 38% of the variance is due to within-person observation-to-observation variation. For the sensitivity analyses, the ICC revealed that 58 – 59% of the variance in same-day arousal and apprehension can be attributed to person-to-person variation (between-person), whereas 41 – 42% of the variance is due to within-person variation.

3.2 The within person association of thought uncontrollability and same-day anxiety

A model was fit to the data that included a fixed effect for person-mean centered thought uncontrollability, a random intercept for subject, and a random slope, which allowed for the association between thought uncontrollability and same-day anxiety to vary across subjects. As hypothesized, greater thought uncontrollability was significantly associated with more severe same-day anxiety symptoms within-person (β = 0.52, 95% CI = 0.43 - 0.62; see Table 3 and Figure 1).

3.3 The within person association of negative valence and same-day anxiety

A model was fit to the data that included a fixed effect for person-mean centered negative valence, a random intercept for subject, and a random slope, which allowed for the association between negative valence and same-day anxiety to vary across subjects. As hypothesized, greater negative valence was significantly associated with more severe same-day anxiety symptoms within person (β = 0.49, 95% CI = 0.38 - 0.60; see Table 3 and Figure 2).

3.4 The within person association of thought uncontrollability and same-day anxiety controlling for negative valence

An initial model was fit to the data that included two fixed effects for person-mean centered negative valence and thought uncontrollability, a random intercept for subject, and two random slopes, which allowed for the association between negative valence and same-day anxiety, as well as thought uncontrollability and same-day anxiety to vary across subjects. Our model did not converge with the random slopes. The inspection of the data revealed low variances for the random slopes for thought uncontrollability ($\tau 11 = 0.17$) and negative valence ($\tau 11 = 0.02$). As a result, we excluded the random slopes and this allowed the model to converge with no singular fit warning.

Only the result from the random intercept model is provided. Greater thought uncontrollability was significantly associated with more severe same-day anxiety symptoms within person (β = 0.42, 95% CI = 0.31–0.52) after controlling for negative valence (β = 0.30, 95% CI = 0.18 – 0.42), see Table 3.

3.5 The within person association of thought uncontrollability and next-day anxiety

An initial model was fit to the data that included a fixed effect for person-mean centered thought uncontrollability, a random intercept for subject, and a random slope, which allowed for the association between thought uncontrollability and next-day anxiety to vary across subjects. Our model did not converge with the random slope. The inspection of the data revealed a low variance for the random slope of thought uncontrollability ($\tau 11 = 0.07$). Thus, we excluded the random slope and this allowed the model to converge with no singular fit warning.

Only the result from the random intercept model is provided. Greater thought uncontrollability was marginally associated with more severe next-day anxiety symptoms within person ($\beta = 0.10$, 95% CI = -0.01–0.21; see Table 3 and Figure 3).

3.6 The within person association of thought uncontrollability and next-day anxiety controlling for same-day anxiety

An initial model was fit to the data that included two fixed effects for person-mean centered thought uncontrollability and same-day anxiety, a random intercept for subject, and two random slopes, which allowed for the associations between thought uncontrollability and next-day anxiety, as well as same-day anxiety and next-day anxiety to vary across subjects. Our model did not converge with the random slopes. The inspection of the data revealed no variance for the random slope for thought uncontrollability ($\tau 11 = 0.00$) and a low variance for same-day anxiety ($\tau 11 = 0.05$). Thus, we excluded the random slopes and this allowed the model to converge with no singular fit warning.

Only the result from the random intercept model is provided. Greater thought uncontrollability was not significantly associated with more severe next-day anxiety symptoms within person (β = 0.03, 95% CI = -0.08 – 0.15) after controlling for same-day anxiety (β = 0.12, 95% CI = 0.07 – 0.18). See Table 3.

3.7 The within person association of thought uncontrollability and next-day anxiety controlling for same-day anxiety and negative valence

An initial model was fit to the data that included three fixed effects for person-mean centered thought uncontrollability, negative valence, and same-day anxiety, a random intercept for subject, and three random slopes, which allowed for the associations between thought uncontrollability and next-day anxiety, same-day anxiety and next-day anxiety, as well as negative valence and next-day anxiety to vary across subjects. Our model did not converge with the random slopes. The inspection of the data revealed low variances for the random slopes for thought uncontrollability ($\tau 11$ = 0.09), same-day anxiety ($\tau 11$ = 0.05), and negative valence ($\tau 11$ = 0.07). Thus, we included only the random intercept in our model. Excluding the random slopes allowed this model to converge with no singular fit warning.

Only the result from the random intercept model is provided. Greater thought uncontrollability was not significantly associated with more severe next-day anxiety symptoms within person (β = -0.02, 95% CI = -0.14 – 0.11) after controlling for same-day anxiety (β = 0.13, 95% CI = 0.07 – 0.19) and negative valence (β = 0.10, 95% CI = -0.04 – 0.23).

3.8 Results from the Sensitivity Analyses

3.8.1 The within person association of thought uncontrollability and same-day arousal

An initial model was fit to the data that included a fixed effect for person-mean centered thought uncontrollability, a random intercept for subject, and a random slope, which allowed for the association between thought uncontrollability and same-day anxious arousal to vary across subjects. Our model did not converge when we included the random slope. The inspection of the data revealed a low variance for the random slope ($\tau 11 = 0.08$). Thus, we excluded the random slope and this allowed the model to converge with no singular fit warning.

Contrary to our hypothesis, greater thought uncontrollability was significantly associated with more severe same-day anxious arousal within person ($\beta = 0.19$, 95% CI = 0.14 – 0.24; see Table 3 and Figure 4).

3.8.2 The within person association of thought uncontrollability and same-day apprehension

An initial model was fit to the data that included a fixed effect for person-mean centered thought uncontrollability, a random intercept for subject, and a random slope, which allowed for the association between thought uncontrollability and same-day anxious apprehension to vary across subjects. Our model did not converge with the random slope. The inspection of the data revealed a low variance for the random slope ($\tau 11 = 0.08$). Thus, we excluded the random slope and this allowed the model to converge with no singular fit warning.

In support of our hypothesis, the random intercept model showed that thought

uncontrollability was significantly associated with more severe same-day anxious apprehension within-person (β = 0.33, 95% CI = 0.27 – 0.39; see Figure 5).

4.0 Discussion

The purpose of this present study was to evaluate the concurrent and prospective associations of two major dimensions of PT—uncontrollability and negative valence — with anxiety symptoms. The overall pattern of findings suggests that greater uncontrollability and negative valence are related to more severe anxiety symptoms within-person on the same day, but do not prospectively predict changes in anxiety from one day to the next. Uncontrollability remained significantly associated with same-day anxiety symptoms even after negative valence was statistically controlled, suggesting that the uncontrollability of thought has implications for mental health symptoms in its own right.

The finding that uncontrollability and negative valence were significantly associated with concurrent anxiety symptoms is consistent with the results from previous studies that have shown positive associations of negative valence (Segerstrom et al., 2008; Hallion et al., 2022) and uncontrollability (Szkodny & Newman, 2019; Hallion et al., 2022) with anxiety symptoms. For example, Bailey and Wells (2013) investigated the relations of metacognition (i.e., uncontrollability) to health anxiety; the results indicated that uncontrollability was significantly related to health anxiety after controlling for age, gender, illness cognition, and neuroticism. Furthermore, the finding that uncontrollability explained additional variance beyond negative valence in anxiety symptoms on the same-day is consistent with a burgeoning empirical literature that has identified uncontrollability as the core characteristic of transdiagnostic PT that is linked to heightened anxiety (e.g., Ehring et al., 2011; Hallion et al., 2022; Szkodny & Newman, 2019).

Additionally, our findings that negative valence was related to same-day anxiety also align

with previous empirical work suggesting that as thought content becomes more negative, so does affect, and more negative thought content is significantly related to increased anxiety (Segerstrom et al., 2003). For instance, our findings are in line with a recent study that used ecological momentary assessment to evaluate the within person relationship of worries and mood shifts among individuals with and without GAD (Newman et al., 2019). That study showed that greater uncontrollability predicted heightened same-day physiological arousal an hour later, controlling for next-hour worry (Newman et al., 2019). It is notable that we found a similar pattern of results with more spaced assessments using our daily diary design. Similar findings from converging methods support the robustness of the within person relationship of negative valence with anxiety.

Our findings also showed that the random slopes, e.g., how the relationship between uncontrollability and anxiety varies per participant, did not converge in most of our models. This suggests that though there is a fair amount of variability in participants' anxiety, the direction and strength of the relationship between uncontrollability and anxiety on the same day is similar across people; that is, the strength of the relationship between uncontrollability and anxiety is stable regardless of an individual's trait anxiety.

One plausible explanation for the positive finding on the within person associations of uncontrollability with same-day anxiety is that the very act of appraising a thought as uncontrollable contributes to anxiety, consistent with predictions from the metacognitive theory of worry (Wells, 1995). Alternatively, uncontrollability may have information processing effects, whereby the onset of uncontrollability may in turn increase the retrieval and accessibility of similarly distressing thoughts (Segerstrom et al., 2003). The uncontrollable thoughts may become ingrained in memory which may contribute to higher anxiety during the day. However, this may not occur over time as we did not see a positive relationship between uncontrollability and anxiety

symptoms the next day. Relatedly, we also found a positive relationship between negative valence and anxiety symptoms on the same day. One tenable explanation for that relationship is that negative valence may enhance a pattern of responses in the environment such as enhanced risk assessment (e.g., hypervigilance) and perceived threats (Hirsch et al., 2015), which are mechanisms that are typically associated with heightened anxiety (McNaughton & Corr, 2004). However, this pattern of response (e.g., hypervigilance) that encompasses negative valence may occur on a shorter duration, but not necessarily over time as we did not see a significant positive relationship of negative valence with anxiety symptoms on the next-day.

Though we found support that greater uncontrollability and negative valence were related to more severe anxiety symptoms on the same day, there may be explanations other than informational processing effects or enhanced risk assessment. For instance, because we only assessed uncontrollability and anxiety once per day, we cannot establish whether uncontrollability prospectively predicts anxiety on a moment-to-moment basis. Thus, it is possible that rather than greater uncontrollability being prospectively related to higher same-day anxiety, the inverse relationship is true; that is, greater anxiety causes more uncontrollability and/or negative valence within person. Another potential explanation for the significant positive relationship of uncontrollability with same-day anxiety could be that lower cognitive control (i.e., the ability to regulate and sequence thoughts and actions in accordance with one's internal goal) (Braver, 2012) may be influencing both uncontrollability and anxiety. Since heightened anxiety levels are associated with lower cognitive control (Hallion et al., 2017), this may underpin increased vulnerability to uncontrollability.

Consistent with the predictions from the meta-cognitive theory of worry (Wells, 1995), i.e., that individuals' appraisal of their thoughts as uncontrollable and dangerous is central to the long-

term development and maintenance of GAD, our findings indicated that greater uncontrollability was related to more severe anxiety on the same-day within person, but did not predict anxiety symptoms the next day. If we had found that greater uncontrollability prospectively predicted anxiety the following day, this would have supported the predictions of the meta-cognitive theory of worry that thought uncontrollability has long-term effects on anxiety. Since we did not find this pattern of result, this indicates that uncontrollability may not have long-term effects on anxiety. Nonetheless, it remains possible that the proposed theoretical relationship of thought uncontrollability and anxiety does exist, but unfolds over a shorter time duration (e.g., hours rather than weeks). More research is needed using multiple timescales., e.g., several assessments of the dimensions of PT and symptoms during the day, to properly map the temporal granularity of how thought uncontrollability relates to anxiety within person.

Contrary to our hypotheses, we did not find that uncontrollability predicted anxiety the following day. A potential explanation for this finding could be that sleep disturbances at night may moderate the relationship of uncontrollability with anxiety the following day. Previous research has indicated that individuals who struggle with intrusive and uncontrollable thoughts while trying to fall asleep are more likely to have sleeping difficulties at night (Harvey, 2000), and this is associated with heightened anxiety the next day (Cox & Olatunji, 2016). For instance, if an individual experiences greater uncontrollability one day, but manages to get adequate sleep at night, their anxiety levels may not be heightened the next day; whereas, if an individual experiences greater thought uncontrollability one day and sleep disturbances during the night, anxiety levels may be heightened the next-day. More specific questions regarding sleep-uncontrollable and distressing thoughts at night may help address this issue in future studies.

We further performed sensitivity analyses to examine whether uncontrollability relates to

fear (i.e., arousal) and stress (i.e., apprehension) differently. Specifically, we hypothesized that greater thought uncontrollability would be associated with lower arousal and higher apprehension on the same-day within person following the predictions of the cognitive avoidance theory (Borkovec & Hu, 1990). The results from our sensitivity analyses did not support our predictions: greater uncontrollability was not related to lower same-day anxious arousal, but rather to higher same-day anxious arousal. This finding is inconsistent with previous work linking higher uncontrollability to lower physiological arousal (Borkovec & Hu, 1990; Peasley-Miklus & Vrana, 2000). Our sensitivity analyses further revealed that greater uncontrollability was significantly related to higher apprehension within person, which is consistent with prior studies linking uncontrollability and higher apprehension (Borkovec et al., 2004). The latter finding provides partial support for the cognitive avoidance theory in that uncontrollability may be related with higher apprehension (Borkovec et al., 1994). Our findings did not find support that arousal and apprehension are differently related to higher uncontrollability. Previous studies that have investigated the cognitive avoidance theory have primarily done so with experimental manipulation studies; these studies have helped us understand that uncontrollability is linked to lower arousal and higher apprehension (Llera & Newman, 2010; Peasley-Miklus & Vrana, 2000). Nonetheless, our study's daily diary design helped control for between person differences (e.g., person-level characteristics), and showed that uncontrollability was related to higher arousal, and not lower arousal, which is inconsistent with previous experimental findings. Our findings suggest that uncontrollability may be differently related to arousal in daily life. To best capture how uncontrollability relates to anxious arousal and anxious apprehension within person over time, more intensive longitudinal work across multiple timeframes (e.g., several assessments during the day) needs to be prioritized.

4.1 Clinical Implications

Our findings may have implications for the treatment of GAD, which is diagnostically characterized by uncontrollable and negatively-valenced thoughts (i.e., worries; American Psychiatric Association, 2013). Among all anxiety disorders, GAD is notably more difficult to treat and a previous meta-analysis demonstrated that about 50% of GAD patients do not respond to treatment (Hunot et al., 2007). Subsequent intervention research can explore whether intervening to improve the controllability of thoughts (or change uncontrollability appraisals) may help to reduce the adverse impact of PT on GAD and other anxiety-related disorders. For instance, researchers could examine the overall effectiveness of pre-existing psychological treatments such as the unified protocol for emotional disorders or mindfulness-based therapy in treating uncontrollability or (change uncontrollability appraisal) for individuals with GAD and other anxiety-related disorders.

4.2 Strengths, Limitations, and Future Directions

The present study is among the first to investigate the independent associations of uncontrollability and negative valence with anxiety symptoms at the within person level. Given that most psychological theories on PT emphasize within-person processes (e.g., meta-cognitive theory, cognitive avoidance theory) (Curran & Bauer, 2021), it is critical that our study evaluated the predictions of these theories using within person processes. Though our study was novel in using a prospective longitudinal daily diary design to evaluate how uncontrollability and negative valence relate to anxiety symptoms within person, several limitations are still evident. First, the

subscale of negative valence consisted of only two items: nervous and happy (reverse-scored), and the internal consistency score was poor ($\alpha = 0.46$). A two-item measure may not have adequately captured the full range of negative valence. Furthermore, the tripartite model of depression and anxiety (Clark & Watson, 1991) suggests that nervous and happy operate as separate heterogeneous constructs of valence for anxiety and depression, respectively. This could explain why reverse-score happy may not be the same construct as sadness, and explain why the internal consistency of negative valence in our study was poor. Second, despite the advantages of using a prospective daily diary design, which limited retrospective reports of thought characteristics and symptoms, we could not evaluate the more specific temporal granularity of how uncontrollability relates to anxiety over time (e.g., within the next hour). For instance, since our finding indicated that uncontrollability and negative valence are related to anxiety symptoms on the same day, this suggests that these associations may be happening in a shorter time frame, i.e., within hours, and we were limited to one daily assessment of thought characteristics and symptoms. Third, we did not utilize any physiological measures of arousal such as using skin conductance to measure anxious arousal. This is important because self-report and physiological measures of anxious arousal are not always correlated (Lang & McTeague, 2009). Lastly, our sample was composed of mainly students, who were also largely white and cis-gender.

An important next step is to utilize a community sample that is more representative of racial groups and non-cisgender individuals to examine how stressors experienced by minoritized individuals may influence how these dimensions of PT relate to anxiety. Moreover, greater demographic diversity would help us determine if and whether our results are generalizable beyond the predominantly white, undergraduate student sample. Future research should utilize methods such as ecological momentary assessment, which could assess the within-person variability of

uncontrollability and negative valence over multiple time points (e.g., several assessments during the day). This would offer more temporal granularity in understanding how these dimensions of PT relate to anxiety over time. Also, it will be important to study how these findings replicate across contexts using ecological momentary assessment designs, which would further support the robustness of the findings that uncontrollability and valence relate to anxiety. More research is also needed to evaluate whether these findings replicate in treatment-seeking samples that are characterized by struggles with PT (e.g., depression, anxiety, PTSD, OCD).

4.3 Conclusion

In conclusion, greater uncontrollability and negative valence were associated with more severe anxiety symptoms on the same-day within person in a student sample. Given the burgeoning evidence linking uncontrollability and negative valence to anxiety, future research should more directly explore the temporal specificity of these relationships. To the extent that both uncontrollability and negative are modifiable risk factors, interventions designed to target both factors may be well-suited for improving anxiety-related problems.

Table 1. Descriptive characteristics of study participants

Variables	***N* = 193**
Age (Mean, (SD), range**)**	19.71 (3.28) 18-49
Perseverative thought measures	
Perseverative thought (trait)	31.13 (12.01) 0-60
Worry (trait)	52.44 (12.41) 20-74
Sex assigned at birth	
Female	122 (63.2%)
Male	71 (36.8%)
Gender	
Man	68 (35.2%)
Woman	121 (62.2%)
Non-binary	5 (2.6%)
Race/Ethnicity	
White	138 (73.4%)
Asian or Asian American	30 (16.0%)
Black or African American	12 (6.4%)
American Indian or Alaska	1 (0.5%)
Native American	0 (0%)
Biracial or Multiracial	7 (3.7%)
Other	5 (2.6%)
Hispanic or Latino	
Yes	12 (6.2%)
No	181 (93.8%)

Table 2. Descriptive information for the within-person daily diary variables

Variables	**Within-person (level 1)**		
	N	**Mean (SD)**	**Range**
Uncontrollability	1656	12.18 (6.25)	3 - 27
Negative Valence	1587	12.38 (4.32)	2 - 18
Same-day Anxiety	2323	15.94 (13.54)	0 - 68
Next-day Anxiety	2137	15.25 (13.39)	0 - 68
Anxious Apprehension	2325	5.94 (6.51)	0 - 38
Anxious Arousal	2323	10.0 (8.18)	0 - 42

Note. The unbalanced N's are attributed to the missingness in the repeat measure designs.

Table 3. The results of the random intercept multi-level models for models 1 through 6

	Same-day Anxiety			Next-day Anxiety		
Predictors	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
	β (SE) p-value	*β (SE) p-value*	*β (SE) p-value*	*β (SE) p-value*	*β (SE) p-value*	*β (SE) p-value*
Fixed Effects						
Intercept	16.91 (0.80) *p*<.001	17.12 (0.82) *p*<.001	17.10 (0.81) *p*<.001	15.29 (0.82) *p*<.001	15.23 (0.81) *p*<.001	15.15 (0.83) *p*<.001
Uncontrollability	0.52 (0.05) *p*<.001	-	0.41 (0.05) *p*<.001	0.10 (0.06) *p*=.09	0.03 (0.06) *p*=.57	-0.02 (0.06) *p*=.79
Negative Valence	-	0.49 (0.06) *p*<.001	0.30 (0.06) *p*<.001	-	-	0.10 (0.07) *p*=.16
Same-day anxiety	-	-	-	-	0.12 0.03 *p*<.001	0.13 (0.03) *p*<.001
Random Effects						
σ2	68.57	68.49	66.14	60.20	59.56	57.66
τ00	112.35	116.40	113.51	115.23	111.52	111.34
ICC	0.62	0.63	0.63	0.66	0.65	0.66
$R^2_{(m)}$/ $R^2_{(c)}$	0.028 / 0.632	0.018 / 0.636	0.034 / 0.644	0.001 / 0.657	0.007 / 0.654	0.008 / 0.662

σ2 = within-person residual variance; τ00 = random intercept variance; ICC = Intraclass Correlation Coefficient; $R^2_{(m)}$ = marginal R^2; $R^2_{(c)}$ = conditional R^2

Table 4. The results of the random intercept multi-level models for the sensitivity analyses

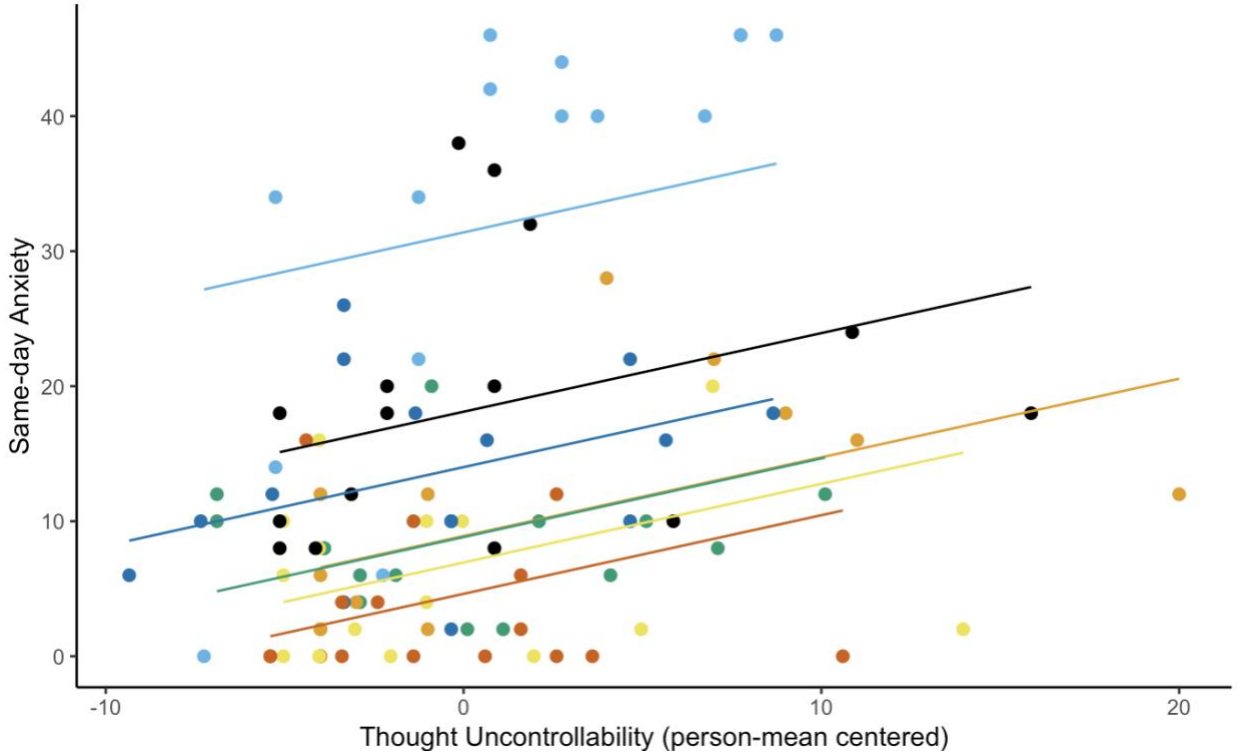
	Same-day	
	Anxious Arousal	**Anxious Apprehension**
Predictors	Model 7	Model 8
	β (SE) p-value	*β (SE) p-value*
Fixed Effects		
Intercept	6.29 (0.38) *p*<.001	10.61 (0.47) *p*<.001
Uncontrollability	0.19 (0.03) *p*<.001	0.33 (0.03) *p*<.001
Random Effects		
σ2	18.07	26.50
τ00	25.02	38.30
ICC	0.58	0.59
$R^2_{(m)}$/ $R^2_{(c)}$	0.016 / 0.588	0.032 / 0.604

σ2 = within-person residual variance; τ00 = random intercept variance
ICC = Intraclass Correlation Coefficient
$R^2_{(m)}$ = marginal R^2
$R^2_{(c)}$ = conditional R^2

Table 5. The results of the random slopes for all the multi-level models

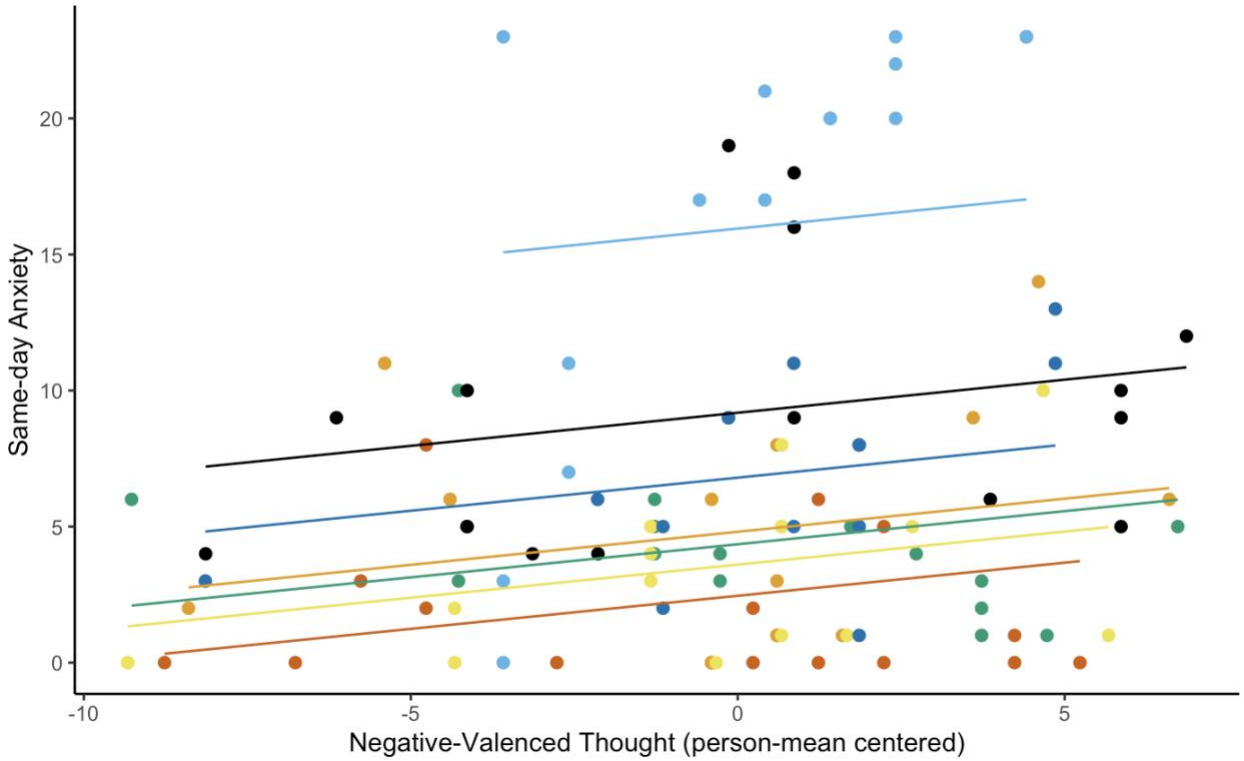
	Same-day Anxiety			Next-day Anxiety			Anxious Arousal	Anxious Apprehension
Predictors	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
	τ11	τ11	τ11	τ11	τ11	τ11	τ11	τ11
Uncontrollability	0.25	0.04	0.17	0.07	0.00	0.09	0.08	0.08
Negative Valence	-	-	0.02	-	0.05	0.05	-	-
Same-day Anxiety	-	-	-	-	-	0.07	-	-

Note. The random slopes for Model 3 through Model 8 come from separate multi-level models which included the random slopes that did not fully converge; τ11 = random slope variance



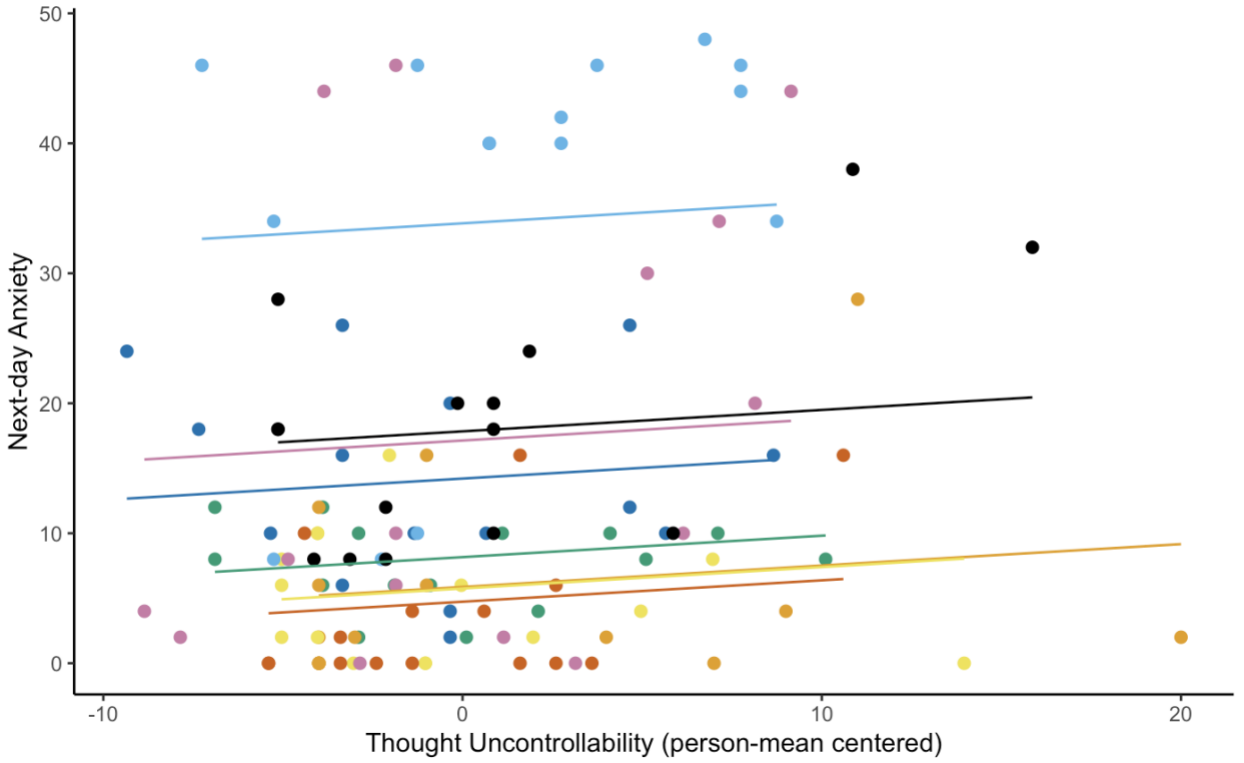
Note. The figures denote a random subset of 8 participants as demonstrated by color; the points represent the raw data; the starting point of the 8 lines represent the varying intercept for the participants (random intercept)

Figure 1. Multi-level modeling result of the within-person association of thought uncontrollability and same-day anxiety symptoms



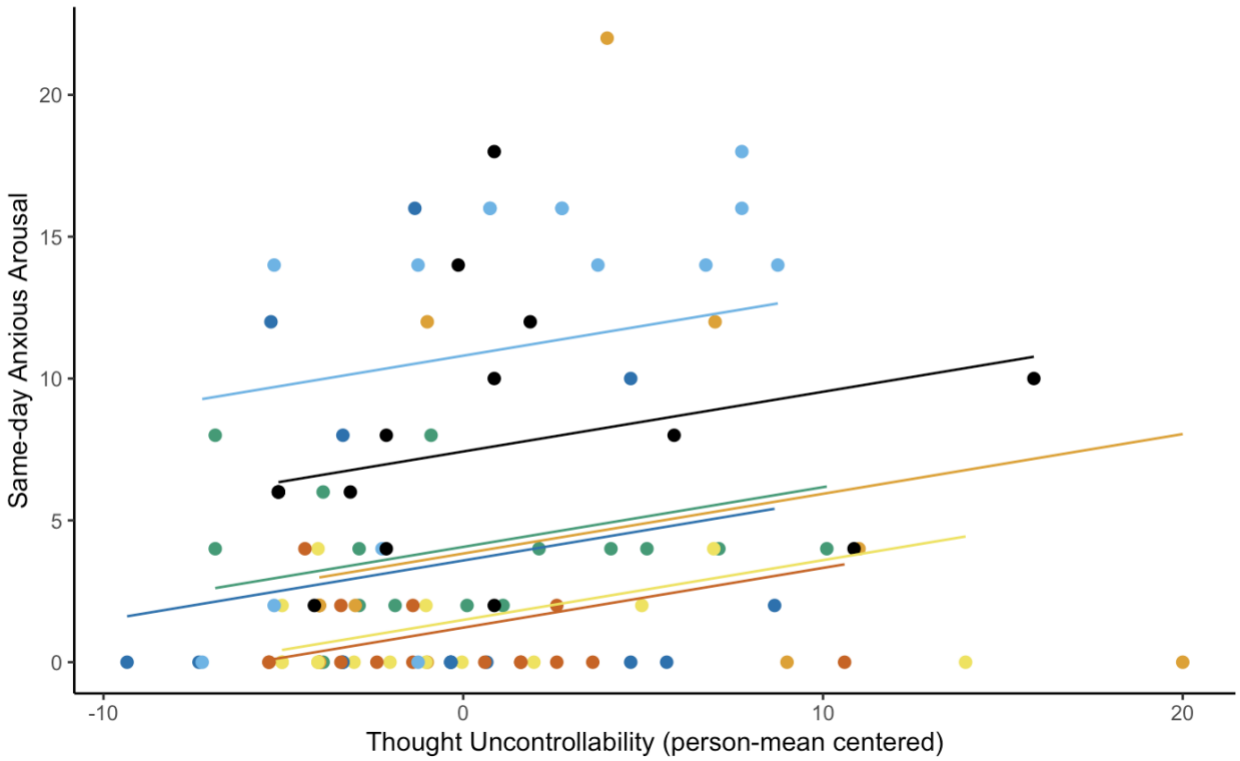
Note. The figures denote a random subset of 8 participants as demonstrated by color; the points represent the raw data; the starting point of the 8 lines represent the varying intercept for the participants (random intercept)

Figure 2. Multi-level modeling result of the within-person association of negative valence and same-day anxiety symptoms



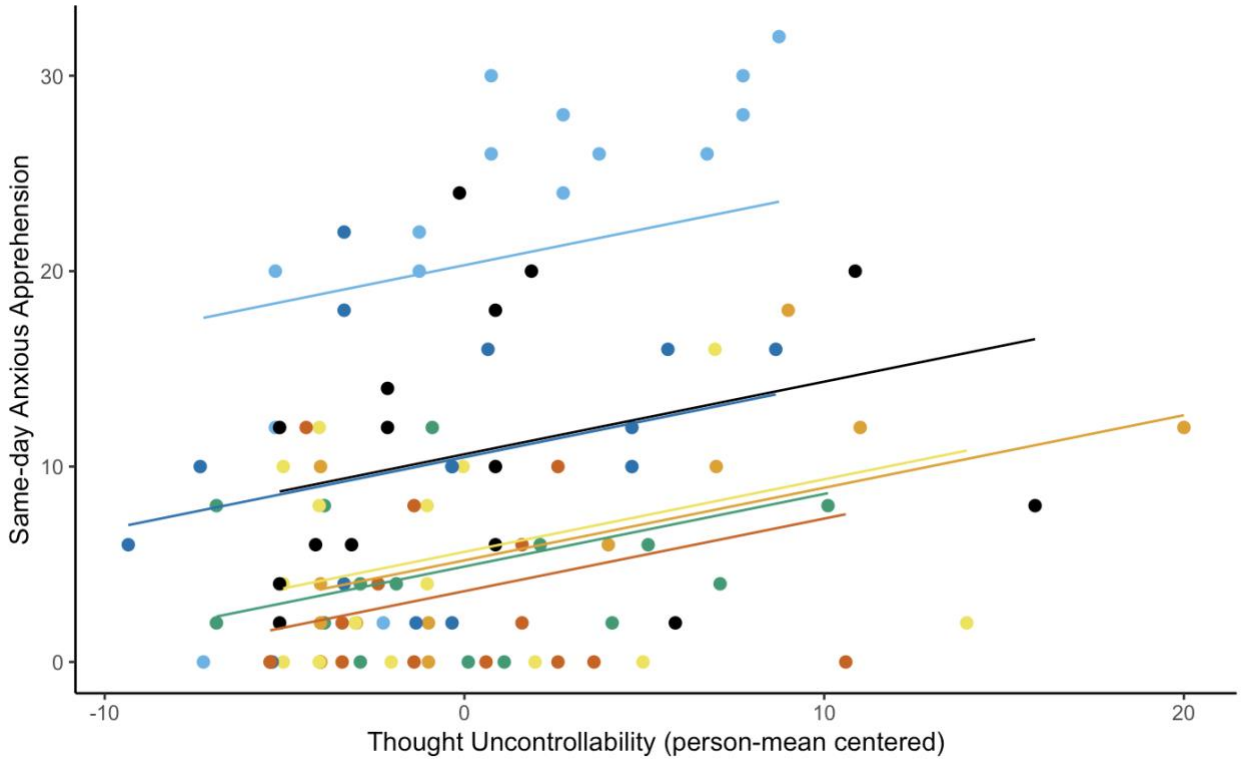
Note. The figures denote a random subset of 8 participants as demonstrated by color; the points represent the raw data; the starting point of the 8 lines represent the varying intercept for the participants (random intercept)

Figure 3. Multi-level modeling result of the within-person association of thought uncontrollability and next-day anxiety symptoms



Note. The figures denote a random subset of 8 participants as demonstrated by color; the points represent the raw data; the starting point of the 8 lines r represent the varying intercept for the participants (random intercept).

Figure 4. Multi-level modeling result of the within-person association of thought uncontrollability and same-day anxious arousal



Note. The figures denote a random subset of 8 participants as demonstrated by color; the points represent the raw data; the starting point of the 8 lines represents the varying intercept for the participants (random intercept)

Figure 5. Multi-level modeling result of the within-person association of thought uncontrollability and same-day anxious apprehension

Appendix A. The MLM equations of the study's hypotheses

Hypothesis 1: Greater thought uncontrollability will be associated with same-day anxiety symptoms, the level-1 predictor (thought uncontrollability) will be centered on the participants' mean thought uncontrollability over the 15-day period (person-mean centered). The equation for hypothesis 1 is as follows:

$$\mathbf{Y_{ij}} = \boldsymbol{\gamma_0} + \boldsymbol{\gamma_1}\mathbf{*X1_{ij}} + \boldsymbol{\beta 1_j} \mathbf{* X1_{ij}} + \mathbf{u_j} + \in_{\mathbf{ij}}$$

$\mathbf{Y_{ij}}$ = same-day anxiety symptoms

$\boldsymbol{\gamma_0}$ = average same-day anxiety symptoms (across all people)

$\boldsymbol{\gamma_1}$ = overall average slope (fixed effect; how strongly person-mean centered thought uncontrollability is associated with same-day anxiety symptoms)

$\mathbf{X1_{ij}}$ = value of thought uncontrollability for observation i from participant j (person-mean centered; this is the value of the within-person variation in thought uncontrollability)

$\boldsymbol{\beta 1_j} \mathbf{* X1_{ij}}$ = where $\beta 1$ is the random slope for individual j (this captures the differences in the relationship of thought uncontrollability and anxiety symptoms from one subject to the next)

$\mathbf{u_j}$ = random intercept for each subject (this captures how the average level of same-day anxiety differs for each subject)

$\in_{\mathbf{ij}}$ = residual error term

Hypothesis 2: Greater negative valence will be associated with more severe same-day anxiety symptoms within person. The level-1 predictor (negative valence) will be centered around

the participants' own mean negative valence over the 15-day period (person-mean centered). The equation is as follows:

$\mathbf{Y_{ij} = \gamma_0 + \gamma_2 * X2_{ij} + \beta 1_j * X2_{ij} + u_j + \in_{ij}}$

$\mathbf{Y_{ij}}$ = same-day anxiety symptoms

$\boldsymbol{\gamma_0}$ = average same-day anxiety symptoms (across all people)

$\boldsymbol{\gamma_{2(\text{negative valence})}}$ = overall slope (fixed effect; how strongly person-mean centered negative valence thought is associated with anxiety symptoms)

$\mathbf{X2_{ij}}$ = value of negative valence for observation i from subject j (person mean centered; this is the value of the within-person variation in negative valence)

$\boldsymbol{\beta 1_j * X2_{ij}}$ = where $\beta 1$ is the random slope for individual j (this captures the differences in the relationship of negative valence and anxiety symptoms from one subject to the next)

$\mathbf{u_j}$ = random intercept for each subject (this captures how the average level of same-day anxiety differs for each subject)

$\mathbf{\in_{ij}}$ = residual error term

Hypothesis 3: Greater thought uncontrollability will be associated with more severe same-day anxiety symptoms within person controlling for negative valence. The equation is as follows: $\mathbf{Y_{ij} = \gamma_0 + \gamma_3 * X3_{ij} + \beta 1_j * X3_{ij} + \gamma_4 * X4_{ij} + \beta 1_j * X4_{ij} + u_j + \in_{ij}}$

$\mathbf{Y_{ij}}$ = same-day anxiety symptoms

$\boldsymbol{\gamma_0}$ =average same-day anxiety symptoms (across all people)

$\boldsymbol{\gamma_{3(\text{thought uncontrollability})}}$ =overall slope (fixed effect; how strongly person-mean centered thought uncontrollability is associated with same-day anxiety symptoms)

$\boldsymbol{\gamma_{4(\text{negative valence})}}$ = overall slope (fixed effect; how strongly person-mean centered negative valence

is associated with same-day anxiety symptoms)

$\mathbf{X3_{ij}}$ = value of thought uncontrollability for observation i from subject j (this is the value of the within-person variation in thought uncontrollability)

$\mathbf{X4_{ij}}$ = value of negative valence for observation i from subject j (this is the value of the within-person variation in negative valence)

$\boldsymbol{\beta 1_j * X3_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of thought uncontrollability to same-day anxiety symptoms)

$\boldsymbol{\beta 1_j * X4_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of negative valence to same-day anxiety symptoms)

$\mathbf{u_j}$ = random intercept for each subject (this captures how the average level of same-day anxiety differs for each subject)

$\in_{ij}$ = residual error term

Since the original model with the random slope did not converge, the updated random intercept MLM equation is as follows: $\mathbf{Y_{ij} = \gamma_0 + \gamma_3 * X3_{ij} + \gamma_4 * X4_{ij} + u_j + \in_{ij}}$

Hypothesis 4: Greater thought uncontrollability will predict higher levels of next-day anxiety symptoms within person. Next-day anxiety (time + 1) is the outcome variable, which will be predicted by same-day thought uncontrollability (person-centered). The equation is as follows:

$\mathbf{Y_{(i+1)j} = \gamma_0 + \gamma_5 * X5_{ij} + \beta 1_j * X5_{ij} + u_j + \in_{ij}}$

$\mathbf{Y_{(i+1)j}}$ = next-day anxiety symptoms

$\boldsymbol{\gamma_0}$ = average next-day anxiety symptoms (across all people)

$\boldsymbol{\gamma_{5(\text{thought uncontrollability})}}$ = overall slope (fixed effect; how strongly person-mean centered thought uncontrollability predicts next-day anxiety symptoms)

$\mathbf{X5_{ij}}$ = value of thought uncontrollability for observation i from subject j (this is the value of the within-person variation in thought uncontrollability)

$\boldsymbol{\beta 1_j * X5_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of thought uncontrollability to next-day anxiety symptoms)

$\mathbf{u_j}$ = random intercept for each subject (how next-day anxiety differs for each participant)

$\in_{\mathbf{ij}}$ = residual error term

Since the original model with the random slope did not converge, the updated random intercept MLM equation is as follows: $\mathbf{Y_{(i+1)j} = \gamma_0 + \gamma_5 * X5_{ij} + u_j + \in_{ij}}$

Hypothesis 5: Greater thought uncontrollability will predict higher levels of next-day anxiety symptoms within person after controlling for same-day anxiety symptoms. Next-day anxiety symptoms (time + 1) is the outcome variable, which will be predicted by same-day thought uncontrollability (person-centered), and covariates for the random slopes for same-day anxiety symptoms. The equation is as follows:

$\mathbf{Y_{(i+1)j} = \gamma_0 + \gamma_6 * X6_{ij} + \beta 1_j * X6_{ij} + \gamma_7 * X7_{ij} + \beta 1_j * X7_{ij} + u_j + \in_{ij}}$

$\mathbf{Y_{(i+1)j}}$ = next-day anxiety symptoms

$\boldsymbol{\gamma_0}$ = average next-day anxiety symptoms (across all people)

$\boldsymbol{\gamma_{6(\text{thought uncontrollability})}}$ = overall slope (fixed effect; how strongly person-mean centered thought uncontrollability predicts next-day anxiety symptoms)

$\boldsymbol{\gamma_{7(\text{same-day anxiety})}}$ = overall slope (fixed effect; how strongly person-mean centered same-day anxiety predicts next-day anxiety symptoms)

$\mathbf{X6_{ij}}$ = value of thought uncontrollability for observation i from subject j (this is the value of the within-person variation in thought uncontrollability)

$\mathbf{X7_{ij}}$ = value of same-day anxiety symptoms for observation i from subject j (this is the value of the within-person variation in same-day anxiety symptoms)

$\boldsymbol{\beta 1_j * X6_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of thought uncontrollability to next-day anxiety symptoms)

$\boldsymbol{\beta 1_j * X7_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of same-day anxiety symptoms to next-day anxiety symptoms)

$\mathbf{u_j}$ = random intercept for each subject (how next-day anxiety differs for each subject)

$\in_{ij}$ = residual error term

Since the original model with the random slope did not converge, the updated random intercept MLM equation is as follows: $\mathbf{Y_{(i+1)j} = \gamma_0 + \gamma_6 * X6_{ij} + \gamma_7 * X7_{ij} + u_j + \in_{ij}}$

Hypothesis 6: Greater thought uncontrollability will predict higher levels of next-day anxiety symptoms, after controlling for same-day anxiety symptoms and negative valence. Next-day anxiety (time + 1) is the outcome variable, which will be predicted by same-day thought uncontrollability (person-centered), and covariates for the random slopes for same-day negative valence and anxiety symptoms. The equation is as follows:

$\mathbf{Y_{(i+1)j} = \gamma_0 + \gamma_4 * X4_{ij} + \beta 1_j * X4_{ij} + \gamma_5 * X5_{ij} + \beta 2_j * X5_{ij} \gamma_6 * X6_{ij} + \beta 6_j * X6_{ij} + u_j + \in_{ij}}$

$\mathbf{Y_{(i+1)j}}$ = next-day anxiety symptoms

$\boldsymbol{\gamma_0}$ = average next-day anxiety symptoms (across all people)

$\boldsymbol{\gamma_{8(\text{thought uncontrollability})}}$ = overall slope (fixed effect; how strongly person-mean centered thought uncontrollability predicts next-day anxiety symptoms)

$\boldsymbol{\gamma_{9(\text{negative valence})}}$ = overall slope (fixed effect; how strongly person-mean centered negative valence predicts next-day anxiety symptoms)

$\gamma_{10(\text{same-day anxiety})}$ = overall slope (fixed effect; how strongly person-mean centered same-day anxiety predicts next-day anxiety symptoms)

$\mathbf{X8_{ij}}$ = value of thought uncontrollability for observation i from subject j (this is the value of the within-person variation in thought uncontrollability)

$\mathbf{X9_{ij}}$ = value of same day negative for observation i from subject j (this is the value of the within-person variation in negative valence)

$\mathbf{X10_{ij}}$ = value of same-day anxiety symptoms for observation i from subject j (this is the value of the within-person variation in same-day anxiety symptoms)

$\boldsymbol{\beta 1_j * X8_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of thought uncontrollability to next-day anxiety symptoms)

$\boldsymbol{\beta 1_j * X9_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of same-day negative valence to next-day anxiety symptoms)

$\boldsymbol{\beta 1_j * X10_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of same-day anxiety symptoms to next-day anxiety symptoms)

$\mathbf{u_j}$ = random intercept for each subject (how next-day anxiety differs for each subject)

$\in_{ij}$ = residual error term

Since the original model with the random slope did not converge, the updated random intercept MLM equation is as follows: $\mathbf{Y_{(i+1)j} = \gamma_0 + \gamma_4 * X4_{ij} + \gamma_5 * X5_{ij} + \gamma_6 * X6_{ij} + u_j + \in_{ij}}$

Sensitivity Analyses

Hypothesis 7: Greater thought uncontrollability will be associated with lower anxious arousal symptoms on the same day within person. Anxious arousal is the outcome variable, which will be predicted by thought uncontrollability (person-mean centered).

$\mathbf{Y_{ij} = \gamma_0 + \gamma_{11}*X1_{ij} + \beta 1_j * X11_{ij} + u_j + \in_{ij}}$

$\mathbf{Y_{ij}}$ = same-day anxious arousal

$\boldsymbol{\gamma_0}$ = average same-day anxious arousal symptoms (across all people)

$\boldsymbol{\gamma_{11}}_{\text{(thought uncontrollability)}}$ = overall slope (fixed effect; how strongly person-mean centered thought uncontrollability is associated with anxious arousal)

$\mathbf{X11_{ij}}$ = value of thought uncontrollability for observation i from subject j (this is the value of the within-person variation in thought uncontrollability)

$\boldsymbol{\beta 1_j * X11_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of thought uncontrollability to anxious arousal)

$\mathbf{u_j}$ = random intercept for each subject (how same-day anxious arousal differs for each subject)

$\in_{\mathbf{ij}}$ = residual error term

Since the original model with the random slope did not converge, the updated random intercept MLM equation is as follows: $\mathbf{Y_{ij} = \gamma_0 + \gamma_{11}*X1_{ij} + u_j + \in_{ij}}$

Hypothesis 8: Greater thought uncontrollability will be associated with higher anxious apprehension symptoms on the same day within person. Anxious apprehension is the outcome variable, which will be predicted by thought uncontrollability (person-mean centered).

$\mathbf{Y_{ij} = \gamma_0 + \gamma_{12}*X12_{ij} + \beta 1_j * X12_{ij} + u_j + \in_{ij}}$

$\mathbf{Y_{ij}}$ = same-day anxious apprehension.

$\boldsymbol{\gamma_0}$ = average same-day anxious apprehension (how strongly person-mean centered thought uncontrollability is associated with anxious apprehension)

$\boldsymbol{\gamma_{12}}_{\text{(thought uncontrollability)}}$ = overall slope (fixed effect; how strongly person-mean centered thought uncontrollability is associated with anxious apprehension)

$\mathbf{X12_{ij}}$ = value of thought uncontrollability for observation i from subject j (this is the value of the within-person variation in thought uncontrollability)

$\boldsymbol{\beta 1_j}$ ***** $\mathbf{X12_{ij}}$ = where $\beta 1$ is the random slope for individual j (this describes the individual relationship of thought uncontrollability to anxious apprehension)

$\mathbf{u_j}$ = random intercept for each subject (how same-day anxious apprehension differs for each subject)

$\in_{ij}$ = residual error term

Since the original model with the random slope did not converge, the updated random intercept MLM equation is as follows: $\mathbf{Y_{ij} = \gamma_0 + \gamma_{12} * X12_{ij} + u_j + \in_{ij}}$

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