The Effects of Worry in Daily Life: An Ecological Momentary Assessment Study Supporting the Tenets of the Contrast Avoidance Model

Michelle G. Newman

Nicholas C. Jacobson, Nur Hani Zainal, Ki Eun Shin, Lauren E. Szkodny, and Martin J. Sliwinski

The Pennsylvania State University

Please cite as: Newman, M. G., Jacobson, N. C., Zainal, N. H., Shin, K. E., Szkodny, L. E., & Sliwinsky, M. (in press). The effects of worry in daily life: An ecological momentary assessment study supporting the tenets of the contrast avoidance model. *Clinical Psychological Science.*

Author Note

Michelle G. Newman, Nicholas C. Jacobson, Nur Hani Zainal, Ki Eun Shin, Lauren E. Szkodny Department of Psychology, The Pennsylvania State University, University Park. Martin J. Sliwinski, Department of Human Development and Family Studies, The Pennsylvania State University, University Park. This data was previously presented at the Anxiety and Depression Association of America (2015) and the Association for Behavioral and Cognitive Therapies (2016). Correspondence regarding this article should be addressed to Michelle G. Newman, 371 Moore Building, The Pennsylvania State University, University Park, PA 16802-3103. Email: mgn1@psu.edu

Abstract

Background: The Contrast Avoidance Model (CAM) suggests that worry increases and sustains negative emotion to prevent a negative emotional contrast (sharp upward shift in negative emotion) and to increase the probability of a positive contrast (shift toward positive emotion). **Method:** In Study 1, we experimentally validated momentary assessment items (*N*=25). In Study 2, participants with generalized anxiety disorder (GAD) (*N*=31) and controls (*N*=37) were prompted once per hour regarding their worry, thought valence, and arousal 10x/day for 8 days. **Results:** Higher worry duration, negative thought valence, and uncontrollable train of thoughts predicted feeling more keyed up concurrently and sustained anxious activation one hour later. More worry, feeling keyed up, and uncontrollable train of thoughts predicted lower likelihood of a negative emotional contrast in thought valence, and higher likelihood of a positive emotional contrast in thought valence one hour later. **Conclusions:** Findings support the prospective ecological validity of CAM.

*General Scientific Summary***:** This paper suggests that naturalistic worry reduces the likelihood of a sharp increase in negative affect and does so by increasing and sustaining anxious activation.

Keywords: Worry, contrast avoidance, generalized anxiety disorder

The Effects of Worry in Daily Life: An Ecological Momentary Assessment Study Supporting the Tenets of the Contrast Avoidance Model

Worry and perseverative thought are transdiagnostic processes that have been linked to negative health effects. These include coronary heart disease (Hamer, Batty, & Kivimaki, 2011; Larsen & Christenfeld, 2009), heightened cortisol response (Arbel, Shapiro, Timmons, Moss, & Margolin, 2017; Reeves, Fisher, Newman, & Granger, 2016), lowered immune reaction (Segerstrom, Glover, Craske, & Fahey, 1999; Segerstrom, Solomon, Kemeny, & Fahey, 1998), sleep problems (Takano, Iijima, & Tanno, 2012; Weise, Ong, Tesler, Kim, & Roth, 2013), and all-cause mortality (Hamer et al., 2011; Phillips et al., 2009). Therefore, understanding more about the function of worry is important.

In the past 30 years, several theories have been proposed to elucidate mechanisms of worry, the main symptom of generalized anxiety disorder (GAD). Such theories include the avoidance theory of worry (Borkovec, Alcaine, & Behar, 2004), intolerance of uncertainty (Freeston, Rheaume, Letarte, Dugas, & Ladouceur, 1994), acceptance-based model (Roemer & Orsillo, 2002), meta-cognitive model (Wells, 1995), and emotion dysregulation model (Mennin, Heimberg, Turk, & Fresco, 2002). Although the models differ in many ways (see Newman & Llera, 2011), they all have in common the notion that worry dampens negative emotion.

In 2011, Newman and Llera diverged from the idea that worry led to avoidance of emotion with their proposal of the Contrast Avoidance Model (CAM; Newman & Llera, 2011). CAM suggests that people with GAD worry to heighten and sustain negative emotion and concomitant arousal in order to avoid a sharp upward negative emotional shift (negative emotional contrast) and to increase the likelihood of a positive emotional contrast. CAM was inspired by studies showing that a negative emotion was experienced as less aversive if preceded by a negative (vs. positive) emotion (Harris, 1929). Similarly, positive emotions were felt more positively if preceded by less positive emotions (Liberman, Boehm, Lyubomirsky, & Ross, 2009). CAM is also consistent with Gray's (1982) Behavioral Inhibition System (BIS) theory, that humans are neurologically predisposed to compare predicted events to those that actually occur and have stronger reactivity when the predicted event is more aversive than expected.

CAM has several basic tenets about worry regardless of GAD status. These include that worry heightens negative emotion (i.e., worry does not dampen concurrent activation or distress). Also, as opposed to worry enabling avoidance of somatic activation or cutting off subsequent activation, CAM proposes that worry increases and sustains activation. Moreover, sustained increased negative emotion associated with worry enables avoidance of a sharp increase in negative emotion. Worry is thus theorized by CAM as a means to pre-empt experiencing a negative emotional contrast. Finally, CAM proposes that worry is motivated by its potential to increase the probability of a positive contrast. Both before and since this theory was proposed, there has been a substantial amount of evidence in support of each of its tenets (see Newman & Llera, 2011; Newman, Llera, Erickson, Przeworski, & Castonguay, 2013 for a complete review).

With respect to worry heightening negative emotion, a worry induction increased self-reported depression and anxiety in unselected samples (Andrews & Borkovec, 1988; Skodzik, Zettler, Topper, Blechert, & Ehring, 2016), chronic worry samples (Andrews & Borkovec, 1988; Borkovec, Robinson, Pruzinsky, & DePree, 1983), those with public speaking anxiety (Borkovec & Hu, 1990) and those with GAD (Llera & Newman, 2014, 2010). Experimentally induced worry led to low vagal tone or high stable heart rate (Ottaviani et al., 2014; Skodzik et al., 2016) and daily worry was associated with heightened anxiety (Dickson, Ciesla, & Reilly, 2012). In fact, in a meta-analysis, worry was associated with higher blood pressure, higher heart rate, lower variability of heart rate, and higher endocrine system activity (Ottaviani et al., 2016b). Moreover, brain studies showed heightened arousal during worry (Andreescu et al., 2015; Ottaviani et al., 2016a; Steinfurth, Alius, Wendt, & Hamm, 2017).

There is also support for the notion that rather than cut it off, worry prolongs negative emotion. For example, ambulatory physiology studies found that worry duration during waking hours predicted higher heart rate (sympathetic arousal) and lower heart rate variability during subsequent sleep (Brosschot, Van Dijk, & Thayer, 2007; Weise et al., 2013). Further, worry episodes led to elevated heart rate both concurrently and up to 2 hours later (Pieper, Brosschot, van der Leeden, & Thayer, 2010) in unselected samples. In addition, both trait and state perseverative cognition led to reduced cardiac recovery from stress (Key, Campbell, Bacon, & Gerin, 2008; Verkuil, Brosschot, de Beurs, & Thayer, 2009). At the same time, those with GAD (vs. controls) were more likely to report that worry created and sustained negative emotion (Llera & Newman, 2017). Trait worry was also associated with sustained hypervigilance to threatening stimuli at a neural level (Burkhouse, Woody, Owens, & Gibb, 2015).

The causal effect of worry on contrast avoidance has also been demonstrated. CAM predicts that worry enables contrast avoidance because it induces and sustains negative emotion and activation (unrelated to any suppression). CAM also suggests that although worry enables contrast avoidance in all individuals, those with GAD are more uncomfortable with a negative emotional contrast than controls. Consistent with the model, regardless of GAD status, induced worry (vs. relaxation) led to increased and sustained sympathetic activation from baseline as well as less of a negative emotional shift when exposed to a stressor based on self-report, sympathetic activation (Llera & Newman, 2014, 2010; Skodzik et al., 2016), and neurologically (Gramszlo & Woodruff-Borden, 2015). Worry, imaginal processing, and relaxation did not lead to significant differences in levels of skin conductance reactivity to a subsequent emotion induction when resting baseline was entered as a covariate (Stapinski, Abbott, & Rapee, 2010). Moreover, absolute level of sympathetic arousal during emotion evocation was the same whether participants had worried or relaxed immediately prior (Llera & Newman, 2014, 2010). Thus, worry led to a reduced negative emotional contrast due to its activating nature as opposed to suppression. A prospective weekly diary study also showed that worry blunted the negative emotional shifts of contrasts (Crouch, Lewis, Erickson, & Newman, 2017). At the same time, those with GAD preferred worry to relaxation to cope with a negative emotional contrast but controls preferred relaxation to worry (Llera & Newman, 2014). In fact, on two measures of contrast avoidance, the probability of a person with GAD scoring higher than somebody without GAD was 96-98% and contrast avoidance predicted GAD diagnosis with a sensitivity of 89.7 and a specificity of 87.5-89.3 (Llera & Newman, 2017). Furthermore, those with GAD were more likely than controls to endorse worrying to avoid the possibility of a negative emotional contrast, discomfort with negative emotional contrasts, and intentionally creating and sustaining negative emotion in order to avoid a negative contrast (Llera & Newman, 2017).

There is also evidence for the final tenet of the model that worry increases the likelihood of a positive emotional contrast. The nonoccurrence of worrisome feared outcomes leading to relief or reduced negative emotion (which happens most of the time; LaFreniere & Newman, 2017), has been theorized to reinforce the propensity to worry in those with GAD (Newman & Llera, 2011). CAM also predicts that rather than suppress or preclude positive emotion, preceding worry would increase the likelihood of experiencing elevation in positive affect. When GAD and control participants worried or relaxed prior to viewing a happy film clip, those who worried showed a larger subsequent positive contrast or increased positive affect, compared to those who had relaxed regardless of GAD status (Kim & Newman, 2016; Llera & Newman, 2014). Those with GAD were also more likely than controls to endorse intentionally worrying to increase the probability of a positive emotional contrast (Llera & Newman, 2017).

Although there is evidence for separate tenets of CAM, most studies were experimental wherein worry was induced (e.g., Llera & Newman 2010; 2014; Verkuil et al., 2009) or involved retrospective recall across a day, a week, or at a trait level (e.g., Crouch et al., 2017; Dickson et al., 2012; Llera & Newman, 2017). Although experimental studies provide greater control, such findings may not be generalizable to effects of real-world worry. Furthermore, all experimental studies examined immediate effects of worry and therefore cannot speak to the impact of worry across longer time periods such as hour to hour. In addition, reliance on retrospective recall may be biased and not accurately capture naturalistic affective fluctuations.

Ecological momentary assessment (EMA) methods reduce the likelihood of retrospective bias. Nonetheless, prior EMA studies of worry, focused on its prolonged cardiac or sleep effects (e.g., Brosschot et al. 2007; Pieper et al., 2010; Weise et al., 2013) as opposed to its impact on negative and positive mood shifts (two central tenets of CAM). Also, such studies did not include those with GAD and therefore cannot speak to whether worry operates the same way in this group. To determine the causal role of real-world worry and its relationship to GAD status, it is thus important to evaluate CAM using ecologically valid methods.

The current study was the first one to examine the relationship of naturalistic worry with positive and negative mood shifts in an EMA study and to include individuals with and without GAD. Our approach used hourly prompted EMA of worry. We first conducted a pilot study to validate the EMA items we used. In the subsequent study, 31 people who met GAD criteria and 37 controls were prompted randomly once per hour to answer questions 10 times per day for 8 days. We predicted that all four tenets of CAM about the causal role of worry would be supported regardless of GAD status. However, we also suspected that GAD status might amplify some of these effects of worry. This was based on evidence that although worry increased activation from baseline in those with and without GAD, GAD individuals exhibited more sympathetic activation during worry than controls (Llera & Newman, 2010).

Study 1

The goal of this pilot experimental study was to validate the items used in Study 2. Few prior EMA studies have assessed the validity of their items as well as made use of items that were specific to their intended constructs. Therefore, we aimed to address this limitation. Another goal was to select the best 3-4 items that participants would complete 10 times per day in order to reduce participant burden.

In particular, we hoped to select one-item measures that best reflected the constructs of worry, anxious activation, and thought valence. Validity was operationalized as the item reflecting a theoretical construct (i.e., worry, anxious activation, or thought valence) that a) had relatively stronger effect sizes in response to appropriate inductions compared to other items within that theoretical domain and b) effect sizes suggested that it best discriminated from baseline as well as between worry, relaxation, stress, sad and happy inductions in expected directions.

Our approach was guided by the circumplex model of affect, which consists of two axes or dimensions, valence and arousal (Posner, Russell, & Peterson, 2005; Russell, 1980). The affect circumplex represents emotions as different blends of valence (negative to positive) and arousal (low to high). Our manipulations reflected varying types of emotion-related states including happiness (positive valence, high arousal), relaxation (positive valence, low arousal), sadness (negative valence, low arousal), stress, and worry (both negative valence, high arousal). Criteria for selecting a thought valence item were how well the item differentiated negatively valenced (sad, stress, and worry) from positively valenced (happy, relax) manipulations as well as between the manipulations and baseline. The worry item was selected based on how well it discriminated the worry manipulation from baseline and was differentiated from other manipulations, especially the stress manipulation for discriminant validity. Criteria for the anxious arousal item included how well the item discriminated high negative arousal manipulations (stress, worry) from baseline and from other manipulations (happy, relaxed, and sad). We paid particular attention to excluding items that showed low differentiation of the target manipulations (worry, stress) from baseline and other manipulations but strong differentiation of the positive arousal (i.e., happy) manipulation from other manipulations including relaxation (positive valence, low arousal).

We did not expect our final item pool to show discriminant validity between items or for items to be statistically independent from one-another, given that worry, negative thought valence, and anxious arousal co-occur and tend to go up and down concurrently.

Methods

Participants. Participants (*N* = 25, 68% female, 83% Caucasian, mean age = 19.13, age range = 18-22) were recruited from a university in the Northeast.

EMA Measure

Experts in perseverative thought generated 13 items that tapped into the following domains: (a) thought valence: *1. To what extent were you thinking negative things? 2. To what extent were you thinking positive things*? *3. Overall, how would you rate your thoughts during the last few minutes?* (b) worry: *4. Were you experiencing a train of thought? 5. Were you* *having thoughts that were difficult to control or stop? 6. To what extent were you having thoughts that took on a life of their own? 7. Were you experiencing a train of thought that you couldn't get out of your head? 8. Were you experiencing a train of thought that was easy to stop? 9. To what extent were you preoccupied with thoughts about things that happened already?* and (c) anxious arousal: *10. To what extent were you feeling keyed up or on edge? 11. To what extent were you feeling excited? 12. To what extent were you feeling aroused? 13. To what extent were you feeling calm?* All items except item 3 were rated on a 0-100 scale from not at all to very much. Item 3 was rated on a 0-100 scale from unpleasant to pleasant.

Manipulation Check Measures

Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990). Before and after the worry induction we administered the PSWQ modified to assess worry on a momentary basis. It has good internal consistency (α = 0.96 for the current study) and good convergent and discriminant validity (Brown, Antony, & Barlow, 1992).

State-Trait-Cheerfulness Inventory (STCI-30, Ruch, Köhler, & van Thriel, 1997)**.** Before and after the happy induction we administered the cheerfulness and bad mood subscales of the state version of the STCI. The STCI has good internal consistency (cheerfulness: α = 0.93; bad-mood: α = 0.92 in the current study), consistent factor structure across populations, and is responsive to momentary mood manipulations.

Ruminative Response Scale (RRS; Nolen-Hoeksema, 2000). Before and after the sad induction, we administered a slightly modified version of the RRS to reflect the last task (i.e. items with the word *think* were changed to *thought*). Internal consistency in the current study was excellent (α = 0.96).

Relaxation Training Questionnaire (RTQ; Peirce, 2014)**.** Before and after the relaxation induction we administered the RTQ, a face-valid 7-item scale that assesses degree of relaxation during the prior task. Items were rated on a 3-point scale (Yes, somewhat, or no). Items included: *Were you able to relax?*, *Were you able to quiet your mind?*, *Did you lose your sense of physical space?*, *Did you notice any change in your breathing?*, *Did your limbs feel numb?*, *Did your thoughts remain quiet, not disturbing*?, *Were you able to ignore any outside noises?* Internal consistency of the RTQ in the current study was adequate (α = 0.78).

Perceived Stress Questionnaire (PSQ; Cohen & Williamson, 1988; Levenstein et al., 1993)**.** Before and after the stress induction, we administered a subset of six of the 10 items from the PSQ chosen because they could be linked to induced stress from the stress manipulation. Items included: *Your problems seem to be piling up*, *You feel discouraged*, *You feel frustrated*, *You feel under pressure from deadlines*, *You feel you're in a hurry*, *You feel that too many demands are being made on you*. Items were rated based on how participants currently felt on a 4-point scale from *not at all* to *very much*. Internal consistency of the PSQ was good (α = 0.85).

Procedure. Participants completed the momentary measures at baseline. They were then given instructions for the following manipulations: (1) worry, (2) stress, (3) sad, (4) relax, and (5) happy. Each induction lasted 5 minutes. The momentary measures were completed after each manipulation. To ensure that results were not driven by order effects, a counterbalanced order of manipulations was randomly assigned. To remove an influence of carryover effects, a mood washout was used, where participants were asked to view a video clip of moving fractal patterns for two minutes in-between each induction.

Worry instructions stated: *I'd like you to think about a topic you've worried most about lately. This could be anything from school to relationships to finances, or anything else that you have worried about the most. In a moment, I will give you a piece of paper and I would like you* *to write down two sentences about your worry topic. In the first sentence describe the content of the worries. In the second sentence please write down why that makes you worried.* Happy instructions were: *I'd like you to think about a topic you've been happiest about lately. This could be anything from a recent weekend, an achievement at school or work, a family gathering, a meaningful activity, or anything else that you have been happiest about. In a moment, I will give you a piece of paper and I would like you to write down two sentences about your happy topic. In the first sentence describe the content of the happiness. In the second sentence please write down why that makes you happy.* Sad instructions included: *I'd like you to think about a topic you've been saddest about lately. This could be anything from a day when things didn't seem to work out, loss of a loved one, loss of a favorite pet, moving apart from your best friend, or anything else that you have been saddest about. In a moment, I will give you a piece of paper and I would like you to write down two sentences about your sad topic. In the first sentence describe the content of the sadness. In the second sentence please write down why that makes you sad.* Relaxation instructions included: *For the next few minutes, I'd like you to shift your breathing so that you breathe from your stomach rather than from your chest. Try to let your stomach rise and fall without expanding your chest. You might want to try placing your hand on your stomach to make sure it is rising and falling. Also, slow your breathing down to a rate slower than usual but not so slow that it is unpleasant or uncomfortable. You might do this by counting from 1 to 3 as you breathe in evenly and then again as you exhale evenly.*

The Paced Auditory Serial Addition Test (PASAT) test was used as a stress induction. The PASAT is a performance-based task. Single digit numbers are presented once every two seconds. Participants are asked to sum the last two spoken numbers upon hearing a new number. For example, if the first two numbers were '5' and '7,' the participant would say '12.' If the next number were '2,' he or she would say '9.' Then if the next number were '3,' he or she would say '5.' A prior study has shown that it is an effective stress manipulation (Lejuez, Kahler, & Brown, 2003).

Planned analyses. We conducted a series of multilevel models to test effects of the manipulations on manipulation checks and on EMA items. There was no missing data and thus, no data replacement strategies were used. Each model included manipulation (i.e. pre, happy, relax, sad, stress, worry) and time (to control for time passage) as fixed effects. Random terms included intercepts and time nested within persons. Post-hoc tests examined least square means for each manipulation on each item and comparison of manipulation differences using the package *phia* (Rosario-Martinez, 2013). All primary fixed effect coefficient's effect sizes were converted to Cohen's *d*, using the following equations for *F*-statistics, *t*-statistics, and chi-squared statistics: $d = ((4\chi^2)/(N-\chi^2))^{1/2}$. Note that effect sizes were the primary metric utilized to choose one best EMA item for each target domain (thought valence, worry, and anxious arousal). We based our decisions on the overall pattern or totality of effect size comparisons between items.

Results

Manipulation Checks

There was a significantly greater amount of worry after the worry manipulation than before (*Least Square M* = 59.20 vs. 47.84; β = 11.360, *SE* = 3.730, $t(24) = 3.046$, $p = .006$). Likewise, the cheerfulness scale of the STCI was higher after the happy induction than before (*Least Square M* = 28.32 vs. 23.28; β = 5.040, *SE* = 1.061, $t(24) = 4.752$, $p < .001$); and the bad mood scale of STCI was lower after the happy induction than before (*Least Square M* = 13.80 vs. 17.96; β = -4.160, *SE* = 0.862, $t(24) = -4.829$, $p < .001$). RRS scores after the sad induction were higher than before (*Least Square M* = 49.80 vs. 42.24; β = 7.560, *SE* = 2.529, $t(24) = 2.989$, $p = .006$). Similarly, RTQ scores were higher after the relaxation induction than before (*Least Square M* = 16.28 vs.12.96; β = 3.320, *SE* = 0.702, $t(24) = 4.768$, $p < .001$). Lastly, PSQ scores were also higher after the stress induction than before (*Least Square M* = 16.28 vs.13.36; β = 1.960, *SE* = 0.805, $t(24) = 2.434$, $p = .023$). Thus, manipulations were successful.

Responsiveness to Manipulations

Thought valence. Each of the thought valence items (1-3) showed a significant response to the manipulations (see Tables 1 and 2). Both item 2 (*To what extent were you thinking positive things*?) and item 3 (*Overall, how would you rate your thoughts during the last few minutes?*) outperformed item 1 (*To what extent were you thinking negative things?*) in differentiating the happy manipulation from baseline and other manipulations (*ds* = .524 – 3.311 for item 1; *ds* = 2.343 – 8.587 for item 2; *ds* = 2.331 – 4.007 for item 3). However, when item 2 and 3 were further compared, item 3 showed greater differentiation of the relaxation manipulation from baseline and negatively valenced manipulations (sad, stress, and worry) (*ds* = .377 – 24.319 for item 3; *ds* = .265 – 5.922 for item 2) as well as overall better differentiation of the three negatively valenced manipulations from baseline (*ds* = 3.905 – 4.572 for item 3; *ds* = 1.546 – 4.941 for item 2). Consequently, item 3 appeared to better represent the construct of thought valence as a whole.

Worry Items. Of the items that assessed uncontrollable trains of thought, 4-7, and 9, showed significant impacts of manipulations (see Tables 1 and 2). However, only item 7 (*Were you experiencing a train of thought that you couldn't get out of your head?*) significantly differentiated worry from stress (d = 1.790), with worry showing a greater response. Item 7 also was significantly higher in response to worry relative to relax (d = 2.072), and although not significant, all other effect sizes suggested that this item was overall more strongly related to worry compared to baseline (*d* = 1.071), happy (*d* = 0.628), and sad (*d* = 0.305) inductions. Based on this, we decided to retain item 7 for the study to follow.

Anxious arousal. Each of the anxious arousal items (10-13) showed significant impacts of the manipulation (see Tables 1 and 2). However, items 11 and 12 were excluded because they appeared to assess happy (positive) arousal and not anxious arousal. Only these two items significantly differentiated the happy manipulation from baseline (*d*s = 3.114 – 5.234) and relaxation (*d*s = 2.895 – 6.831) while simultaneously failing to differentiate negatively valenced manipulations from relaxation (*ds* = .185 - .912). Of the remaining two items, item 10 had stronger effect sizes in discriminating stress (*ds* = .404 – 3.293) and worry (*ds* = .603 – 5.833) from baseline and stress/worry from happy, relax, and sad manipulations than item 13 (*ds* = .190 – 3.486 for stress; *ds* = .126 – 3.632 for worry). Thus, item 10 was retained for the second study.

Discussion

The goal of this study was to validate momentary assessment items that would reflect valence of thoughts, anxious activation and worry. Few prior EMA studies have assessed the validity of their items as well as to make use of items that were specific to their intended constructs. Another goal was to select only 3-4 items that participants would complete 10 times per day in order to reduce participant burden. Therefore, this pilot study helped set the stage for our subsequent EMA study.

Related to thought valence, the item *Overall, how would you rate your thoughts during the last few minutes* rated on a 0-100 scale from unpleasant to pleasant best differentiated happy, sad, and worry states. Related to worry the item *Were you experiencing a train of thought that you couldn't get out of your head?* rated from 0 *not at all* to 100 *very much* best differentiated worry from stress, and relaxation. Related to the item reflecting anxious arousal, *To what extent were you feeling keyed up or on edge?* rated from 0 *not at all* to 100 *very much* best discriminated anxious arousal from baseline, relaxation, sadness, and happy manipulations. Thus, these 3 items were retained for Study 2.

Study 2

Method

Participants

Between 2013 and 2016, 8,183 people were screened with the GAD-Q-IV (Newman et al., 2002) through a subject pool from a university. Requiring fulfillment of inclusion criteria (i.e., meeting diagnostic criteria for GAD or not meeting criteria, interest in participating in our study, and willingness to respond to 10 prompts per day) resulted in a final sample of N = 68 (31 with GAD, 37 controls; 87% female, 81% Caucasian; mean age 18.78, age range 18-22).

Measures

Generalized Anxiety Disorder Questionnaire IV (GAD-Q-IV; Newman et al., 2002)**.** This 9-item self-report scale diagnoses GAD using Diagnostic and Statistical Manual versions IV and 5 criteria (American Psychiatric Association, 1994; American Psychiatric Association, 2013). Receiver Operating Characteristic analyses showed 89% specificity and 83% sensitivity when compared to structured interview diagnoses of those with GAD, social phobia, panic disorder, and nonanxious controls. The GAD-Q-IV had internal consistency (α = .94), 2-week retest reliability (92% of the sample showed stability across time), convergent and discriminant validity, and kappa agreement of .67 with a structured interview. Penn State Worry Questionnaire (PSWQ) (Meyer, Miller, Metzger, & Borkovec, 1990) scores of undergraduates identified as having GAD on the GAD-Q-IV were not significantly different from baseline PSWQ scores in a treatment seeking community sample (see Newman et al., 2002). The 31 participants with GAD in the current study met full GAD diagnostic criteria which is a more stringent criterion than the original 5.7 cutoff endorsed by Newman et al. (2002). Using this criterion, Newman et al. (2002) found 96% specificity and 67% sensitivity in detecting GAD. Also, in a primary care psychotherapy-seeking sample Moore et al. (2014) found that requiring participants to meet full DSM-IV criteria was the optimal strategy for identifying GAD (with a sensitivity of .89 and specificity of .82).

Momentary Measure of Worry. The 3 validated items from Study 1 reflected thought valence: (1) *How would you rate your thoughts during the past five minutes?* Responses: *Unpleasant (0) – Pleasant (100)*, anxious arousal: (2) *Did you feel keyed up or on edge during the past hour?* Responses: *Not at all (0) – Very much* (100), and worry: (3) *Did you experience a train of thought you couldn't get out of your head during the past hour?* Responses: *Not at all (0) – Very much (100).* We added an additional item to capture worry duration: (4) *How much time did you spend worrying during the past hour?* Responses: *Less than 5 minute*s, *5 – 15 minutes*, *15 – 30 minutes*, *30-45 minutes*, and *45-60 minutes*. Positive and negative emotional contrasts were operationalized by difference in valence of thoughts between one prompt and the prompt one hour later. This led to negative numbers representing a positive contrast in thought valence (valence of thoughts getting more positive) and positive numbers representing a negative contrast in thought valence (valence of thoughts getting more negative). However, we wanted to create separate variables to represent negative and positive contrasts in thought valence so they would not cancel each other out in our analyses. Therefore, we split this into two variables by (1) applying a 0 value for all contrasts at or below zero to define the negative contrast in thought valence variable (any level of positive contrast was coded as an absence of negative contrast), and (2) applying a 0 value for any contrast at or above 0 to define the positive contrast in thought valence variable (any negative contrast represented a complete absence of a positive contrast) and then taking the absolute values (such that all values were framed to be positive). Thus, the separate positive and negative contrast in thought valence variables ranged from 0 (representing no contrast) to 100 (representing a total contrast).[1] Arousal was operationalized as feeling keyed up and on edge. We also examined worry in terms of its duration (number of minutes spent worrying in the last hour), controllability (level of uncontrollability of train of thoughts), and negative valence .

Procedure

Participants were selected based on their GAD status as well as their interest in participating in the study and willingness to carry a Smartphone and respond to hourly prompts for eight days. They were then scheduled for a training procedure where they consented to participate. They received an Android phone and a charger and were instructed how to complete the items with an opportunity to ask any questions. They were told to expect random prompts once per hour beginning at 11 AM and ending at 8 PM, resulting in a total of 10 prompts per day.[2] They were asked to answer prompts as quickly as possible. After two days, they returned to the lab to check whether they were having trouble with prompts, to answer any questions, and to check on their compliance. They then continued the EMA for the next six days. After eight days

[1] The between-subject correlation between positive and negative contrasts was $r = 0.18$, and the within-person correlation was $r = -0.38$. This suggests that only 3.24% of the variation in negative contrasts can be explained by variation in positive contrasts across persons, and only 14.44% of the variation in negative contrasts can be explained by variation in positive contrasts within persons. Thus, positive and negative contrast constructs demonstrated discriminant validity from one another.

[2] In our effort to balance participant burden (no more than 10 prompts per day) with compliance (starting prompts late morning for late sleepers and ending early evening when young adults are most likely to be responsive to prompts) and to increase the likelihood of capturing worry by prompting every hour, we began prompting at 11 AM and terminated prompting at 8 PM. Although worrying often occurs immediately before bed, it tends to start when trying to fall asleep and we did not want to interfere with sleep. It was not our goal to capture all worry that happened but instead to capture a sufficient amount of typical daily dimensional worry to be able to examine its hourly naturalistic associations.

had elapsed, they returned the phones and chargers.

Compliance

Overall compliance rate was 69.2% (median number of prompts completed = 53 of 80, range = 33 to 80).

Planned Analyses

To ensure that we had requisite power, we conducted a Monte Carlo data simulation. Data were simulated to mirror the current sample and cell size and to include person-specific differences in the outcome (to mirror the lack of independence of errors necessitating the use of multilevel modeling). The simulation also included the same type and degree of missingness, as the current sample. We used a standardized effect size of 0.2 for the predictor on the outcome, and for differential moderation between the GAD group and controls. Across 1,000 Monte-Carlo simulations, we had 99% power to detect both within-person main effects and interactions between GAD and within-person process variables.

Multilevel models using the R packages *lme4* and *lmertest* (Bates, Maechler, & Bolker, 2012; Kuznetsova, Brockhoff, & Christensen, 2015) were conducted. Missing data (31%) was handled via full information maximum likelihood. We first calculated intraclass correlations (ICCs) using multilevel models to ensure sufficient within-person variation to allow us to test within-person process hypotheses. ICCs were calculated using the following model:

$$outcome_{t,i} = \gamma_{0,0} + u_{0,i} + e_{t,i} \tag{1}$$

Here *t* represents the time period, and *i* represents the individual. The term $outcome_{t,i}$ reflects the predicted later effect for each time period and each individual. The term $\gamma_{0,0}$ represents the grand intercept in the outcome of all persons, the term $u_{0,i}$ represents the random intercept for each person and $e_{t,i}$ represents the residual error term for each person at each time period. Note that the $u_{0,i}$ term is assumed to be independent and normally distributed with a mean of 0 and a variance of σ_0^2 (i.e. $u_{0,i} \sim iid\ N\ (0, \sigma_0^2)$ for subject *i*); similarly, the term $e_{t,i}$ is assumed to be independently and normally distributed, with a mean of 0 and a variance of σ^2 (i.e. $e_{t,i}\ \sim iid\ N\ (0, \sigma^2)$ for subject *i* at time *t*). The intraclass correlation (ICC) is defined as $ICC = \frac{\sigma_0^2}{(\sigma_0^2 + \sigma^2)}$, and thus represents the proportion of total variance in the outcome explained by stable between-subject differences. This leaves all other variance as due to within-person differences. ICCs near 1 suggest that almost all within-sample variation is due to stable individual differences (and therefore would make evaluating process data problematic). In contrast, ICCs lower than 0.5 suggest greater levels of within-person variation compared to between-person variation.

Following calculation of ICCs, we ran six multilevel models examining worry in terms of its duration, negative thought valence, and controllability of train of thoughts in predicting concurrent and sustained feeling keyed up or on edge. For each model, interactions between GAD status with these variables were treated as fixed effects. Each model controlled for the following covariates which were also entered as fixed effects: (1) age, (2) gender, (3) time of day, (4) day in the study, and (5) concurrent effects (for all lagged analyses).[3] In the second phase, there were six multilevel models, separately examining ratings of worry duration, keyed up, and uncontrollable train of thoughts in predicting avoidance of a negative contrast in thought valence or increased likelihood of a positive contrast in thought valence. Within each model we examined interactions of variables with GAD status, coded via a dummy variable (0 = Controls, 1 = GAD). Hourly assessments were person-standardized so that all analyses reflected within-

[3] When these covariates were removed, the same pattern of findings remained significant.

person variability. Further, within-person standardization results reflected number of standard deviations in the outcome from one change in standard deviation of the predictor.

The following model equation was used in predicting concurrent effects (i.e. only for the keyed-up variable):

$$keyedup_{t,i} = \gamma_{0,0} + \gamma_{1,0} * worry_{t,i} + \gamma_{2,0} * GAD_{0,i} + \gamma_{3,0} * worry_{t,i} * GAD_{0,i} + \gamma_{4,0} * Time_{t,i} + \gamma_{5,0} * Day_{t,i} + \gamma_{6,0} * Gender_{0,i} + \gamma_{7,0} * Age_{0,i} + u_{0,i} + e_{t,i} \quad (2)$$

Here *t* represents the time period, and *i* represents the individual. The term $keyedup_{t,i}$ reflects the outcome. *Worry* is a placeholder for each multilevel model to indicate the impact of either worry duration, negative thought valence or train of thoughts. The term $\gamma_{0,0}$ represents the grand intercept in the outcome for all persons, $\gamma_{1,0}$ represents the impact of concurrent $worry_{t,i}$ for all persons, $\gamma_{2,0}$ represents the impact of GAD status on the outcome, and $\gamma_{3,0}$ represents the interaction between concurrent worry and GAD status in predicting the outcome. The terms $\gamma_{4,0}$, $\gamma_{5,0}$, $\gamma_{6,0}$, and $\gamma_{7,0}$ control for effects of time of day, day in the study, gender, and age on the outcome, respectively. The term $u_{0,i}$ represents the random intercept for each person and $e_{t,i}$ represents the residual error term for each person at each time period.

In predicting lagged effects, the following model equations were used:

$$outcome_{t,i} = \gamma_{0,0} + \gamma_{1,0} * worry_{t-1,i} + \gamma_{2,0} * GAD_{0,i} + \gamma_{3,0} * worry_{t-1,i} * GAD_{0,i} + \gamma_{4,0} * worry_{t,i} + \gamma_{5,0} * worry_{t,i} * GAD_{0,i} + \gamma_{6,0} * Time_{t,i} + \gamma_{7,0} * Day_{t,i} + \gamma_{8,0} * Gender_{0,i} + \gamma_{9,0} * Age_{0,i} + u_{0,i} + e_{t,i} \quad (3)$$

Here *t* represents the time period, and *i* represents the individual. The term $outcome_{t,i}$ reflects the predicted later effect of the outcome for each individual (note that the outcome could included keyed-up/on edge, positive contrasts in thought valence, and negative contrasts in thought valence). Note that *worry* is a separate placeholder for each multilevel model to indicate the impact of either worry duration, negative thought valence[4] and train of thoughts. The term $\gamma_{0,0}$ represents the grand intercept in the outcome for all persons, $\gamma_{1,0}$ represents the impact of prior *worry* for all persons, $\gamma_{2,0}$ represents the impact of GAD status on the outcome, and $\gamma_{3,0}$ represents the interaction between prior worry and GAD status in predicting the outcome. The terms $\gamma_{3,0}$ and $\gamma_{4,0}$ control for the impact of concurrent worry and the interaction between concurrent worry and GAD status in predicting the outcome. Likewise, the terms $\gamma_{6,0}$, $\gamma_{7,0}$, $\gamma_{8,0}$, and $\gamma_{9,0}$ control for the effects of time of day, day in the study, gender, and age on the outcome, respectively. The term $u_{0,i}$ represents the random intercept for each person and $e_{t,i}$represents the residual error term for each person at each time period.[5]

We made Bonferroni corrections to control for type I error rates of multiple tests related to our hypotheses. This resulted in the following alpha thresholds for each outcome: (a) α =

[4] Note that negative thought valence was also used to predict both positive and negative contrasts in thought valence. However, these results are only included in footnotes, because negative thought valence is used to derive positive and negative contrasts, and therefore, these results are expected to some degree given that they are derived from some of the same raw values. For this reason, we decided to report results of analyses where negative thought valence was a predictor for contrast avoidance outcomes only in footnotes.

[5] All models were also re-run including a random slope term ($u_{1,i}$), and all of the main effects of the results remained significant and in the same direction as presented below. Nevertheless, the two significant interaction terms were no longer significant when the random slope term was included. Specifically, the interaction between GAD status and worry duration became non-significant in predicting concurrent keyed-up (*ß* = 0.093, *SE* = 0.074, t = 1.253, p = .216, d = 0.306). Likewise, the interaction between GAD status and negative thought valence also became non-significant in predicting concurrent keyed-up (*ß* = 0.111, *SE* = 0.062, t = 1.783, p = .079, d = 0.436). However, essentially both the random slopes and the moderation interaction are attempting to explain the same variation in the outcome. Specifically, individual differences in the predictions of worry on the outcomes necessarily incorporate the between-person differences which could otherwise be moderated by GAD status. Consequently, it's not surprising that this interaction becomes nonsignificant when both are included in the model. In fact, Barr, Levy, Scheepers, and Tily (2013, page 275) have noted that *in most cases, one should also have by-unit random slopes for any interactions where all factors comprising the interaction are within-unit; if any one factor involved in the interaction is between-unit, then the random slope associated with that interaction cannot be estimated, and is not needed*. Given this, we believe that our original modeling framework better estimates the impact of GAD status on worry predicting the outcomes.

0.05/6 = 0.008 for concurrent keyed-up; (b) α = 0.05/6 = 0.008 for subsequent keyed-up; (c) α = 0.05/8 = 0.006 for negative contrasts in thought valence; and (d) α = 0.05/8 = 0.006 for positive contrasts in thought valence. In order to determine if contrast results were due to ceiling effects, we also calculated the frequency of reaching a ceiling on any outcome measure during any level of worry above zero.

Results

Intraclass Correlations

Intraclass correlations were 0.390 for worry duration, 0.292 for negative thought valence, 0.482 for uncontrollable trains of thoughts, and 0.434 for keyed-up. Thus, only 3.0-48.2% of the variation was explained by stable individual differences, suggesting that 51.8-97% was due to within-person variation.

Concurrent Arousal

All results are listed in Table 3. As hypothesized, longer worry duration (*ß* = 0.503, *SE* = 0.020, *t* = 24.825, *p* < .001, *d* = 6.066), more negative thought valence (*ß* = 0.442, *SE* = 0.019, *t* = 23.597, *p* < .001, *d* = 5.766), and greater levels of uncontrollable trains of thought (*ß* = 0.512, *SE* = 0.018, *t* = 28.372, *p* < .001, *d* = 6.932) were associated with being more keyed-up concurrently. These main effects were qualified by significant two-way interactions between GAD status and worry duration (*ß* = 0.088, *SE* = 0.030, *t* = 2.903, *p* = .004, *d* = 0.709), and GAD status and negative thought valence (*ß* = 0.092, *SE* = 0.029, *t* = 3.167, *p* = .002, *d* = 0.774). There was also an interaction between GAD status and uncontrollability of trains of thought (*ß* = 0.061, *SE* = 0.028, *t* = 2.179, *p* = .029, *d* = 0.533) in predicting feeling concurrently keyed-up, which was no longer significant following the Bonferroni correction. Simple slopes showed that the relationship between worry duration and keyed up was stronger for those meeting GAD status (*ß*

= 0.591, *SE* = 0.022, *t* = 26.317, *p* < .001, *d* = 6.430), compared to controls (*β* = 0.503, *SE* = 0.020, *t* = 24.825, *p* < .001, *d* = 6.066). Similarly, the association between negative thought valence and keyed up was stronger among those meeting GAD status (*β* = 0.535, *SE* = 0.022, *t* = 23.836, *p* < .001, *d* = 5.824), compared to controls (*β* = 0.442, *SE* = 0.019, *t* = 23.597, *p* < .001, *d* = 5.766). Thus, on average there was an association between worry duration, degree of negative thoughts, and level of uncontrollable trains of thought with concurrent arousal. Nonetheless, effects of worry duration and degree of negative thoughts were amplified in those with GAD.

Sustained Arousal

As with concurrent findings, longer worry duration (*ß* = 0.093, *SE* = 0.025, *t* = 3.745, p < .001, *d* = 0.915), higher negative thought valence (*ß* = 0.082, *SE* = 0.023, *t* = 3.617, *p* < .001, *d* = 0.884), and higher level of uncontrollable trains of thought (*ß* = 0.111, *SE* = 0.023, *t* = 4.949, *p* < .001, *d* = 1.209) predicted still feeling keyed-up one hour later. There were no significant two-way interactions between GAD status and worry duration (*ß* = -0.060, *SE* = 0.038, *t* = -1.576, *p* = .115, *d* = -0.385), valence of thoughts (*ß* = 0.011, *SE* = 0.036, *t* = 0.299, *p* = .765, *d* = 0.073), and uncontrollability of trains of thought (*ß* = -0.016, *SE* = 0.035, *t* = -0.450, *p* = .653, *d* = -0.110) in predicting still feeling keyed-up one hour later. Thus, for those with and without GAD on average, greater worry duration, higher negative thought valence, and higher levels of uncontrollable trains of thoughts predicted higher levels of sustained arousal an hour later.

Negative Contrast in Thought Valence

Supporting our hypothesis, longer worry duration (*ß* = -0.098, *SE* = 0.035, t = -2.766, *p* = .006, *d* = -0.676), being more keyed up (ß = -0.105, SE = 0.032, t = -3.271, p = .001, d = -0.799), and higher level of uncontrollable trains of thought (*ß* = -0.091, *SE* = 0.032, *t* = -2.871, *p* = .004, *d* = -0.701) in the last hour each predicted a lesser negative contrast in thought valence in the next hour. Accounting for Bonferroni corrections, there were no significant interactions between GAD status and worry duration (*ß* = -0.100, *SE* = 0.053, *t* = -1.902, *p* = .057, *d* = -0.465), GAD status and keyed up (*ß* = -0.022, *SE* = 0.049, *t* = -0.456, *p* = .649, *d* = -0.111), or GAD status and uncontrollability of train of thoughts (*ß* = -0.032, *SE* = 0.048, *t* = -0.667, *p* = .505, *d* = -0.163) on contrast avoidance. Thus, for the whole sample on average there was a significant association between worry duration, degree of feeling keyed up, and degree of uncontrollable train of thoughts with avoidance of a negative contrast in thought valence in the next hour.[6]

Positive Contrast in Thought Valence

Supporting our hypothesis, longer worry duration (*ß* = 0.222, *SE* = 0.036, *t* = 6.243, *p* < .001, *d* = 1.525), being more keyed up (*ß* = 0.254, *SE* = 0.032, *t* = 8.038, *p* < .001, *d* = 1.964), and higher level of uncontrollable trains of thought (*ß* = 0.193, *SE* = 0.031, *t* = 6.146, *p* < .001, *d* = 1.502) each individually predicted greater positive thought valence contrast in the next hour. Accounting for Bonferroni corrections, there was no interaction between GAD status and: worry duration (*ß* = 0.023, *SE* = 0.053, *t* = 0.431, *p* = .667, *d* = 0.105), keyed up (*ß* = 0.020, *SE* = 0.048, *t* = 0.409, *p* = .683, *d* = 0.100), and uncontrollable trains of thought (*ß* = 0.005, *SE* = 0.048, *t* = 0.108, *p* = .914, *d* = 0.026) on positive contrast in thought valence. Thus, on average there was a significant association between degree of worry duration, degree of feeling keyed up, and levels of uncontrollable trains of thought with increased likelihood of a positive contrast in thought valence in the next hour.[7]

[6] Consistent with our hypotheses, higher negative thought valence (*ß* = -0.384, *SE* = 0.029, *t* = -13.303, *p* < .001, *d* = -3.250) also predicted a lesser negative contrast in thought valence in the next hour. As noted above, however, negative thought valence contrasts and negative thought valence included some of the same raw values, and consequently this result should be interpreted with a caution due to possibly being a methodological artifact.

[7] Consistent with our hypotheses, higher levels of negative thought valence (*ß* = 0.662, SE = 0.026, *t* = 25.821, *p* < .001, *d* = 6.309) predicted greater positive thought valence contrast in the next hour. However, we repeat the same caveat that positive thought valence contrasts and negative thought valence were based on some of the same raw values, and this overlap may drive the observed effect.

Checking Whether the Findings Can Be Attributed to Ceiling Effects

We found that on *negative thought valence* people reached a ceiling 2.71% of the time concurrent with any level of worry and 2.4% one hour following a worry episode. For *keyed up or on edge* this occurred 2.95% of the time concurrent to worry, and 2.3% of the time subsequent to worry. Thus, during and following worry episodes, keyed up and negative thought valence were below the ceiling about 97% of the time, suggesting that negative contrast avoidance results were not driven by a ceiling effect from worry periods.

Discussion

Using ambulatory methods, our findings buttress and provide ecological validity for basic assumptions of CAM. In Study 1 (see supplement for full description), our experimental approach to validate the EMA items was an important strength that overcomes limitations of using non-validated single-item measures. Among thought valence indicators, ‘degree of pleasantness’ most strongly differentiated negative (sad, stress, worry) from baseline and from positive (happy, relax) inductions. The worry manipulation also successfully effected five items that captured repetitive thinking, but only ‘uncontrollable train of thoughts’ notably distinguished worry from stress. For anxious arousal, only ‘feeling keyed up or on edge’ differentiated worry and stress from baseline, sad, happy, and relaxation inductions. Indeed, most worriers experience feeling keyed up (e.g., approximately 89%; Andrews et al., 2010), rendering this item an important effect of worry versus other mood inductions. Thus, we retained only those items that appeared to be most reflective of the intended constructs and added a worry duration item.

In Study 2, we found that longer worry duration, higher level of negative thought valence, and greater uncontrollability of train of thoughts, irrespective of GAD status on average, predicted higher concurrent and greater sustained anxious arousal during the next hour (when controlling for next hour worry). Concurrent findings are consistent with large negative links among perceived emotional control and worry severity (Gallagher, Bentley, & Barlow, 2014). Prospective results are concordant with EMA data (Brosschot et al., 2007; Pieper et al., 2010) wherein worry periods in unselected participants were associated with lowered heart rate variability concurrently and in the following hours. Overall, findings provide additional support for the notion that rather than enable negative emotional avoidance, worry evokes and sustains negative emotion and anxious arousal.

Worry duration, feeling concurrently keyed up, and uncontrollable train of thoughts also predicted avoidance of a negative contrast in thought valence. This supports the basic CAM position, wherein worry functions to sidestep experiencing a sharp increase in negative emotions but does so by increasing and sustaining anxious activation. Accordingly, prior studies showed that worry created anxious states in daily anxiety (Dickson et al., 2012), and experimentally lowered the probability of negative contrasts for those with and without GAD (Llera & Newman, 2010; 2014).

Similarly, worry duration, concurrent arousal, and uncontrollable train of thoughts heightened the probability of experiencing positive emotional contrasts (increased positive thoughts) an hour later. As worry evokes negative affect, and often involves predictions that do not come true (LaFreniere & Newman, 2017), it would increase the probability of experiencing acute brief elevations in positive affect, which would reinforce worry. Our real-world results speak clearly to this CAM notion and align with prior experiments (Kim & Newman, 2016; Llera & Newman, 2014). This is an important novel finding given the paucity of studies on positive valence systems in GAD (Craske, 2012). CAM nonetheless posits that distress linked to positive mood states would eventually emerge after moments of pleasure abate as worriers now find themselves susceptible to negative emotional contrasts. Discomfort with negative contrasts may in turn cause high worriers to revert to more familiar and less threatening negative affect (Newman et al., 2013). Correspondingly, a treatment study documented considerable challenges to boosting and sustaining positive affect in GAD (Bosley, Fisher, & Taylor, 2016). Entrenched distorted cognitions such as, *I enjoyed success the most when I worried about failure* (Llera & Newman, 2017) may maintain pathological worry.

GAD status heightened the association of worry duration, and negative thought valence in predicting feeling concurrently (but not sustained one hour later) keyed up. However, these findings were no longer significant when we controlled for the random slopes in the interaction. Presence of GAD also led to a trend toward strengthening the relationship of worry duration and subsequent negative contrast avoidance with a medium effect size. However, these effects were also not significant following Bonferroni corrections and random slope controls. Given that heightened presence, duration, and severity of worry are core symptoms in those with GAD, GAD status may be redundant with the predictors tested here. Nonetheless, reluctance of those with GAD to non-judgmentally allow dynamic shifts in emotions may motivate and maintain their chronic worry relative to those without GAD (Mankus, Aldao, Kerns, Mayville, & Mennin, 2013). A vicious cycle of chronic prolonged worry and arousal, reinforced by negative contrast avoidance or positive contrast, may make such worry familiar territory for those with GAD.

It should be noted that although consistent with CAM, prior theories might also predict that worry could lead to a reduced negative emotional contrast one hour later. However, where the theories diverge would be regarding whether this were due to heightened and sustained arousal as suggested by CAM or whether this were due to aspects of worry or GAD that led to dampening of distressing emotion. Our study supports that contrast avoidance occurred because worry elevated anxious activation concurrently and sustained anxious activation one hour later. Similarly, both CAM and other theories have suggested that worry is negatively reinforcing. Whereas CAM suggests that this is due to increased likelihood of a positive contrast, other theories suggest this is due to worry reducing some somatic activation and associated distress. Our findings are most supportive of the former explanation. In addition, whereas some theorists suggest that GAD is a disorder of emotional avoidance, our finding of worry increasing the probability of a positive contrast for everyone on average, suggests that neither the state of worry nor clinical levels of GAD predicted dampening of positive emotion.

There might also be potential methodological explanations for our findings. For example, because worry led to elevated anxiety, there was less room for increased anxiety one hour later. This is true, however, our findings showed that any reduced negative contrast in thought valence was not due to a methodological artifact of a ceiling effect 97% of the time. At the same time, being higher on anxious activation also meant greater likelihood for decreased anxious activation one hour later and our findings of sustained anxious arousal in the subsequent hour were not consistent with this likely outcome. Nonetheless, negative affect from worry also meant more room for increased positive affect in the subsequent hour and this could explain increased likelihood of a positive contrast. CAM suggests that these likely outcomes are exactly the dysfunctional coping logic used by chronic worriers. *If I expect the worst, then I will be emotionally braced for it and such worry will reduce the likelihood of a strong negative emotional shift. At the same time, I increase the likelihood that I will be pleasantly surprised*.

In most prior experimental studies (Kim & Newman, 2016; Llera & Newman, 2014), the impact of worry on negative, and positive contrasts was assessed within a very short window of time (i.e., a few minutes) and with reference to an emotionally evocative stimulus. The one diary study of CAM retrospectively examined effects of worry on stressors across the prior week (Crouch et al., 2017). In the current study, however, we sampled time on an hourly basis regardless of whether participants encountered a subsequent stressor. Thus, our study adds to prior studies by showing what worry might predict after an hour whether or not a stressor occurred. Our findings suggest the possibility that a subsequent stressor may not be necessary for worry to reduce negative contrasts. Perhaps anticipation of feared outcomes typical of worry and its effect on sustained arousal is sufficient for the body and mind to react as though the threat had occurred. However, future EMA studies should incorporate assessment of stressors and nonoccurrence of feared outcomes.

The preponderance of data presented thus far indicates that negative contrast avoidance is a potential treatment target for GAD. Currently existing treatments have shown limited success, with meta-analytic evidence that only about 50% of GAD patients respond to treatment (Hunot, Churchill, Teixeira, & Silva de Lima, 2007). Targeting underlying mechanisms of worry (e.g., contrast avoidance) may improve treatment outcomes. Several therapeutic techniques have been proposed to address contrast avoidance in a cognitive behavioral therapy framework (Newman, Llera, Erickson, & Przeworski, 2014). For instance, therapists can provide psychoeducation on the self-defeating nature of worry i.e., although worry lowers negative contrasts, it impairs quality of life by prolonging negative emotions. Therapists can also employ imaginal exposure to negative contrasts. Clients would first engage in relaxation and then imagine feared scenarios to expose themselves to a sharp increase in negative emotions. To this end, clients learn to tolerate sharp negative contrasts without engaging in preemptive worrying and simultaneously learn to *let go* while deploying relaxation skills. Further, therapists can help GAD clients to challenge and modify their tendency to underestimate their ability to cope with negative contrasts and metaphorically *roll with the punches*. Importantly, these interventions were directly derived from basic science findings on CAM, and deserve empirical testing of their efficacy in GAD.

Several limitations deserve mention. First, replication in treatment-seeking samples is warranted. The current sample also consisted of young adults and consequently had a restricted age range, and thus, replication in samples representing a wider range of age groups is warranted. Further, although our statistical analyses were adequately powered, the study would still benefit from replication with a larger sample. In addition, our targeted time frame for assessment (11 AM to 8 PM) likely missed worry that occurred earlier in the morning and upon awakening for those who were earlier risers and that occurred after 8 PM. Although we would not expect that such assessments would lead to different associations with worry than what we found here, future studies might incorporate different time frames and experiment with longer intervals between prompts. Also, in experiments (e.g., Llera & Newman, 2014), GAD participants were differentiated from controls based on their endorsement of worry being more helpful than relaxation in coping with a negative emotional contrast. Controls, however, preferred to cope with relaxation over worry. Such perceptions of worry likely relate to GAD patients' frequent engagement in it and may partly explain observed interactions with GAD status. Future EMA work might incorporate participants' perception of the utility of worry in preventing negative contrasts or intentional use of worry to control contrasts. Also, examination of other psychopathologies would elucidate whether contrast avoidance applies to other disorders.

These limitations notwithstanding, this was the first study to test CAM comprehensively using EMA. Our findings extend previous experimental and weekly diary studies on CAM, supporting its ecological validity. Additional strengths include experimental validation of momentary assessment items, frequent sampling across hours to assess the unfolding of contrast avoidance within days, and comparison of the effects of worry on associated arousal between individuals with and without GAD. Elucidating the underlying mechanisms of worry such as contrast avoidance could eventually lead to improvements in GAD treatment.

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Table 1

Impact of Manipulation on the Momentary Measure of Worry Items from Study 1

			Post-Hoc Effect Size Comparisons				
#	*F*		Baseline	Happy	Relax	Sad	Stress
1	*F*(5, 219.000) = 20.252*	Happy	2.060*				
		Relax	0.854	-0.524			
		Sad	-2.797*	-2.501*	-2.832*		
		Stress	-0.404	-2.034*	-1.035	6.484*	
		Worry	-3.882*	-3.311*	-39.975*	0.91	-1.283*
2R	*F*(5, 213.264) = 23.670*	Happy	2.905*				
		Relax	0.265	-8.587*			
		Sad	-4.941*	-2.343*	-5.922*		
		Stress	-1.546*	-2.619*	-1.409*	0.804	
		Worry	-1.996*	-2.534*	-1.730*	0.619	-0.154
3R	*F*(5, 213.334) = 29.885*	Happy	3.031*				
		Relax	0.377	-4.007*			
		Sad	-4.572*	-2.353*	-24.319*		
		Stress	-4.011*	-2.450*	-3.059*	0.34	
		Worry	-3.905*	-2.331*	-6.365*	-0.093	-0.438
4	*F*(5, 219.000) = 9.882*	Happy	-1.426*				
		Relax	3.512*	4.244*			
		Sad	-1.520*	-0.030	-4.098*		
		Stress	0.753	2.112*	-0.888	2.216*	

		Worry	-0.433	0.603	-3.162*	0.637	-0.974
5	*F*(5, 213.210) = 4.095*	Happy	-0.586				
		Relax	0.978	1.355			
		Sad	-1.065	-0.291	-1.978*		
		Stress	0.210	0.628	-0.541	0.990	
		Worry	-1.058	-0.292	-2.001*	-0.001	-0.993
6	*F*(5, 210.014) = 4.189*	Happy	-0.328				
		Relax	1.668*	1.579*			
		Sad	-0.438	-0.078	-1.745*		
		Stress	1.047	1.097	-0.284	1.212	
		Worry	-0.370	-0.030	-1.669*	0.048	-1.153
7	*F*(5, 211.451) = 4.005*	Happy	-0.167				
		Relax	1.017	0.913			
		Sad	-0.578	-0.303	-1.363		
		Stress	0.845	0.781	-0.106	1.191	
		Worry	-1.071	-0.628	-2.072*	-0.305	-1.790*
8R	*F*(5, 210.780) = 0.803	Happy	0.663				
		Relax	-0.010	-0.509			
		Sad	0.091	-0.428	0.077		
		Stress	-0.388	-0.846	-0.286	-0.367	
		Worry	-0.035	-0.531	-0.019	-0.097	0.269
9R	*F*(5, 213.494) = 5.886*	Happy	-0.304				
		Relax	-0.481	-0.132			

		Sad	3.116*	2.395*	2.999*		
		Stress	-0.869	-0.39	-0.253	-6.862*	
		Worry	0.422	0.579	0.733	-1.124	1.063
10	*F*(5, 212.839) = 9.418*	Happy	0.786				
		Relax	0.694	-0.057			
		Sad	-1.107	-1.749*	-1.606*		
		Stress	-2.204*	-3.293*	-2.905*	-0.404	
		Worry	-3.293*	-5.833*	-4.696*	-0.603	-0.183
11	*F*(5, 212.150) = 17.380*	Happy	-3.114*				
		Relax	1.101	2.895*			
		Sad	5.460*	2.445*	0.736		
		Stress	0.081	7.085*	-0.729	-1.905*	
		Worry	0.629	3.366*	-0.291	-1.125	0.411
12	*F*(5, 212.235) = 9.567*	Happy	-5.234*				
		Relax	0.83	4.210*			
		Sad	1.178	3.416*	0.185		
		Stress	-0.184	2.408*	-0.791	-1.038	
		Worry	-0.300	2.107*	-0.912	-1.172	-0.089
13R	*F*(5, 212.421) = 12.622*	Happy	0.39				
		Relax	2.828*	1.112			
		Sad	-1.683*	-1.690*	-4.351*		
		Stress	-2.386*	-2.189*	-3.486*	-0.190	
		Worry	-2.088*	-1.997*	-3.632*	-0.126	0.064

Note. * $p < .050$ These depict results from multilevel models. Note that all post-hoc comparison statistics represent Cohen's *d*s. 1. To what extent were you thinking negative things? 2R. To what extent were you thinking positive things? 3R. Overall, how would you rate your thoughts during the last few minutes? 4. Were you experiencing a train of thought? 5. Were you having thoughts that were difficult to control or stop? 6. To what extent were you having thoughts that took on a life of their own? 7. Were you experiencing a train of thought that you couldn't get out of your head? 8R. Were you experiencing a train of thought that was easy to stop? 9R. To what extent were you preoccupied with thoughts about things that happened already? 10. To what extent were you feeling keyed up or on edge? 11. To what extent were you feeling excited? 12. To what extent were you feeling aroused? 13R. To what extent were you feeling calm?

Table 2

Least Square Means from Study 1 Manipulations

	Baseline	Happy	Relax	Sad	Stress	Worry
#	*M*	*M*	*M*	*M*	*M*	*M*
1	2.200	1.476	1.803	3.630	2.398	3.095
2R	2.827	1.450	2.696	3.911	3.434	3.532
3R	2.688	1.386	2.507	3.767	3.557	3.825
4	2.751	3.463	1.684	3.487	2.322	3.010
5	2.012	2.280	1.593	2.456	1.913	2.457
6	2.150	2.286	1.611	2.328	1.764	2.302
7	2.145	2.229	1.687	2.423	1.756	2.619
8R	3.378	2.995	3.384	3.323	3.608	3.399
9R	3.447	3.625	3.726	2.454	3.917	3.202
10	2.064	1.711	1.747	2.527	2.772	2.885
11	2.268	3.552	1.792	1.352	2.229	1.974
12	1.732	2.630	1.413	1.314	1.807	1.855
13R	2.999	2.798	2.137	3.671	3.800	3.757

Note. # Refers to item number within the study. R following the item number suggests that the item was reverse scored. These least squares means were derived from the multilevel models (see planned analyses). 1. To what extent were you thinking negative things? 2R. To what extent were you thinking positive things? 3R. Overall, how would you rate your thoughts during the last few minutes? 4. Were you experiencing a train of thought? 5. Were you having thoughts that were difficult to control or stop? 6. To what extent were you having thoughts that took on a life of their own? 7. Were you experiencing a train of thought that you couldn't get out of your head? 8R. Were you experiencing a train of thought that was easy to stop? 9R. To what extent were you preoccupied with thoughts about things that happened already? 10. To what extent were you feeling keyed up or on edge? 11. To what extent were you feeling excited? 12. To what extent were you feeling aroused? 13R. To what extent were you feeling calm?

Table 3

Main Effects and Interactions from Study 2

Predictor	Outcome	Main Effect *β (SE)*	Interaction[a] *β (SE)*
Worry Duration	Concurrent Keyed-Up	0.503 (0.020)*	0.088 (0.030)*
Negative Thought Valence	Concurrent Keyed-Up	0.442 (0.019)*	0.092 (0.029)*
Uncontrollable Trains of Thoughts	Concurrent Keyed-Up	0.512 (0.018)*	0.061 (0.028)
Worry Duration	Subsequent Keyed-Up	0.230 (0.027)*	0.043 (0.041)
Negative Thought Valence	Subsequent Keyed-Up	0.198 (0.024)*	0.030 (0.039)
Uncontrollable Trains of Thoughts	Subsequent Keyed-Up	0.259 (0.025)*	0.001 (0.039)
Worry Duration	Subsequent Negative Contrast in Thought Valence	-0.082 (0.029)*	-0.090 (0.042)
Keyed-Up	Subsequent Negative Contrast in Thought Valence	-0.071 (0.025)*	-0.079 (0.039)
Uncontrollable Trains of Thoughts	Subsequent Negative Contrast in Thought Valence	-0.056 (0.025)	-0.063 (0.039)
Worry Duration	Subsequent Positive Contrast in Thought Valence	0.203 (0.029)*	0.057 (0.042)
Keyed-Up	Subsequent Positive Contrast in Thought Valence	0.231 (0.025)*	0.044 (0.038)
Uncontrollable Trains of Thoughts	Subsequent Positive Contrast in Thought Valence	0.155 (0.025)*	0.063 (0.039)

Note. * Significant based on a Bonferroni correction. [a] Interaction between predictor and GAD status. Note that these multilevel model estimates also simultaneously control for the fixed effects of gender, age, time of day, day in the study, as well as the random intercept.