

# Anger-Reduction Treatment Reduces Negative Affect Reactivity to Daily Stressors

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**Objective:** Negative affect (NA) reactivity to daily stressors may confer health risks over and above stress exposure, especially in chronically angry adults. This randomized controlled trial tests the hypothesis that a 12-week cognitive-behavioral therapy (CBT) anger-reduction treatment would decrease NA reactivity to daily stressors assessed via ambulatory diary for those in treatment, but not on a wait-list for treatment. **Method:** Healthy adults ( $N = 158$ , aged 20–45 years, 53.20% women) scoring high on Spielberger's (1988) Trait Anger, a scale from the State-Trait Anger Expression Inventory, were randomly assigned to a CBT treatment or wait-list control group, and completed 24 hr of prerandomization and postintervention ecological momentary assessment (EMA) of NA intensity and stress events every  $20 \pm 5$  min. A longitudinal model using a generalized estimating equation examined whether stressor exposure and NA reactions to momentary stressors changed from pre- to posttreatment in the CBT group. **Results:** There was a significant 3-way interaction ( $t_{28} = 2.29, p = .03$ ) between stressor, treatment group, and EMA day, indicating that NA reactivity decreased for the treatment group 1.60 points more than for the wait-list group (a 379.38% greater change in NA reactivity). NA during stressors was 1.18 points lower (a 28.42% decrease) for the treatment group at EMA Day 2 ( $p = .04$ ), whereas wait-list NA during stressors nonsignificantly increased. **Conclusion:** CBT to decrease chronic anger is associated with lower NA reactivity to daily stressors in this sample and could be a promising treatment to mitigate the health impact of stress in this clinical population.

## What is the public health significance of this article?

Chronic anger and negative reactions to stress can increase health risks. This study suggests that a commonly used psychotherapy treatment to help decrease persistent feelings of anger is also associated with lower negative feelings (including irritation, anxiety, and sadness) when a person encounters a stressful event in his or her daily life.

**Keywords:** trait anger, stress reactivity, ecological momentary assessment, cognitive-behavioral therapy, negative affect

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Stress is a complex reaction to an internal or external agent experienced as a threat to an individual's well-being that causes him or her to recruit cognitive, affective, and physiological systems for the restoration of homeostasis and safety (Lazarus, 1993). Although stress responses can be adaptive, the association between stress exposure and markers of physical health risk, such as inflammation, is well established for both acute stress studied in laboratory settings (Kamarck et al., 1997; Marsland, Walsh, Lockwood, & John-Henderson, 2017) and chronic daily stress that persists over time (Richardson et al., 2012; Rosengren et al., 2004; Steptoe & Kivimäki, 2013; Sumner et al., 2016).

Recent longitudinal evidence suggests that the health-compromising effects of stress may derive not only from exposure to stress but also from affective reactivity to that exposure, that is, the magnitude of an individual's emotional response to a stressful event (Bolger & Zuckerman, 1995; Charles, Piazza, Mogle, Sliwinski, & Almeida, 2013; Mroczek et al., 2015). In a longitudinal study of 435 participants from the National Study of Daily Experiences (Almeida, 2017) who completed a series of daily diary interviews between 1995 and 1996, greater affective reactivity to daily stressors, but not frequency of exposure to daily stressors, was associated with an increased risk of reporting a chronic physical health condition 10 years later (Piazza, Charles, Sliwinski, Mogle, & Almeida, 2013). A cross-sectional analysis of data from 872 participants in that same study revealed that people who reported greater reductions in positive affect had elevated levels of inflammation indexed by Interleukin-6 on days when they reported stressors, even after controlling for relevant covariates and stressor frequency (Sin, Graham-Engeland, Ong, & Almeida, 2015). These data suggest that affective responses to daily stress, over and above exposure to that stress, may have effects on health.

Daily stress events can be associated with changes in multiple types of negative affect (NA; including, but not limited to, anxiety, sadness, and anger), depending on the nature of the external threat (Schilling & Diehl, 2014). Internal consistency between different types of momentary NA has emerged (Crawford & Henry, 2004; Merz et al., 2013) in studies using scales such as the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). For this reason, Schilling and Diehl (2014) have called NA the "domain of choice" for measuring the impact of daily stressors (p. 73) in both momentary and trait-NA studies (Bleil, Gianaros, Jennings, Flory, & Manuck, 2008). However although associations between stress and NA have been explored in various nonclinical (Montpetit, Bergeman, Deboeck, Tiberio, & Boker, 2010; Schilling & Diehl, 2014) and clinical samples (Peeters, Nicolson, Berkhof, Delespaul, & deVries, 2003), NA reactivity to stress in the chronic anger population has not received similar attention.

As Bolger (1990) proposed, individual differences in personality can influence patterns of stress exposure, affective reactions to stress, and coping choices, adding nuance to the understanding of why the experience of stress is a greater risk for some than for others. For example, several studies have found that the association between stress and NA is moderated by levels of trait neuroticism (Bolger & Schilling, 1991; Bolger & Zuckerman, 1995; Mroczek & Almeida, 2004) and individual differences in coping and resilience resources (Montpetit et al., 2010). Trait anger and hostility have been associated with adverse cardiac health outcomes in previously healthy populations (Everson-Rose et al., 2014; Williams, Nieto, Sanford, & Tyroler, 2001) and poorer

outcomes for patients with coronary heart disease (e.g., Chida & Steptoe, 2009; Kucharska-Newton et al., 2014). Stress exposure and reactivity patterns therefore become a compelling focus for clinical intervention in the high-trait-anger population.

Chronic anger is characterized by anticipatory monitoring of perceived slights, attacks, or unjust actions on the part of others (Barazzone & Davey, 2009; Gardner & Moore, 2008; Owen, 2011). Coupled with this habitual interpersonal vigilance, some studies have shown increased intensity and duration of anger responses to daily provocations for those higher in trait anger (Tafate, Kassinove, & Dundin, 2002) and hostility (Enkelmann et al., 2005; Smith, Glazer, Ruiz, & Gallo, 2004; Vella, Kamarck, Flory, & Manuck, 2012). Following Bolger and Zuckerman's (1995) model of a differential exposure-reactivity model, we proposed that high trait anger and hostility increase both the likelihood of daily stressor exposure and the magnitude of emotional reactivity to that exposure, compromising an individual's ability to effectively regulate his or her NA response to daily stress. This formulation suggests that a cognitive-behavioral therapy (CBT) intervention to shift cognitive frameworks and impart skills for reducing reactivity may mitigate the health risks associated with high trait anger.

NA reactivity to stressors lends itself to an ecological momentary assessment (EMA) approach to the investigation of the stressor-affect relationship (Kamarck et al., 2005; Tennen, Afleck, & Armeli, 2005). Although there is a strong evidence base for CBT as an effective treatment for decreasing chronic anger (Lee & DiGiuseppe, 2018), the inclusion of EMA monitoring in a randomized controlled trial of CBT for questionnaire-assessed trait anger addresses the need for greater ecological validity, identified in a recent review of the literature (Fernandez, Malvaso, Day, & Guharajan, 2018). In particular, the use of EMA allows a comparison of NA at moments with and without reported stressors to quantify reactivity in daily life before and after the CBT intervention. In this paper, we examined the association between stressor exposure and NA intensity on a moment-to-moment basis in a treatment study of adults high in trait anger and hostility, which significantly reduced trait-anger scores for those in the CBT condition, but not the wait-list condition (Sloan et al., 2010). We also examined whether a CBT treatment protocol to reduce hostility would alter the association between ambulatory measures of NA and current stressful events during one day of EMA monitoring. Specifically, we hypothesized that (a) NA would be higher during current relative to nonstress moments for both groups on both EMA days, and that after 12 weeks of CBT treatment, those in the treatment group would have (b) lower NA on EMA Day 2 during current stress moments than the wait-list group, and (c) lower NA reactivity during current stressor moments compared with non-stressor moments, whereas the wait-list group would not have lower NA reactivity.

## Method

### Study Design

The parent study was a randomized controlled trial to test the hypothesis that a 12-week CBT anger- and hostility-reduction treatment would increase cardiac autonomic regulation in participants who were high in Trait Anger (Spielberger, 1988) and

Hostility (Cook & Medley, 1954), as measured by two standard assessments (see Sloan et al., 2010). Participants completed a 24-hr ambulatory monitoring to assess affect intensity and stressor exposure during waking hours at study entry and again after the intervention. These EMA data form the basis for the present study (see Figure 1 for a CONSORT diagram), which was approved by the New York State Psychiatric Institute Institutional Review Board.

**Participants**

Participants were recruited from the New York City area via print, Internet, and radio advertisements to receive a “free anger-management treatment program” as part of their participation in a research study. Data collection lasted from November 2000 to February 2005. Initially eligible participants were between the ages of 20 and 45 years of age, with a body-mass index 32 or less,

and had no significant medical problems. Participants were required to score  $\geq 26$  on the 50-point Cook-Medley Hostility Scale (Cook & Medley, 1954), and  $\geq 25$  on the 30-point Trait Anger scale of the Spielberger State-Trait Anger Expression Inventory (STAXI) questionnaire (Spielberger, 1988), assessed at an initial appointment after participants provided informed consent.

Study clinicians then interviewed each initially eligible participant individually before randomization to assess the suitability of CBT treatment for their presenting anger problems. During this interview, the clinician assessed treatment goals and psychiatric history to rule out serious clinical issues, including current major depressive disorder, anxiety disorder, past or current suicidal ideation or self-injurious behavior, personality disorders, and substance-use disorders. The clinician also reviewed the study protocol with each participant, including the possibility of randomization to the wait-list condition. Participants who were deemed to need immediate treatment or for whom the CBT protocol was

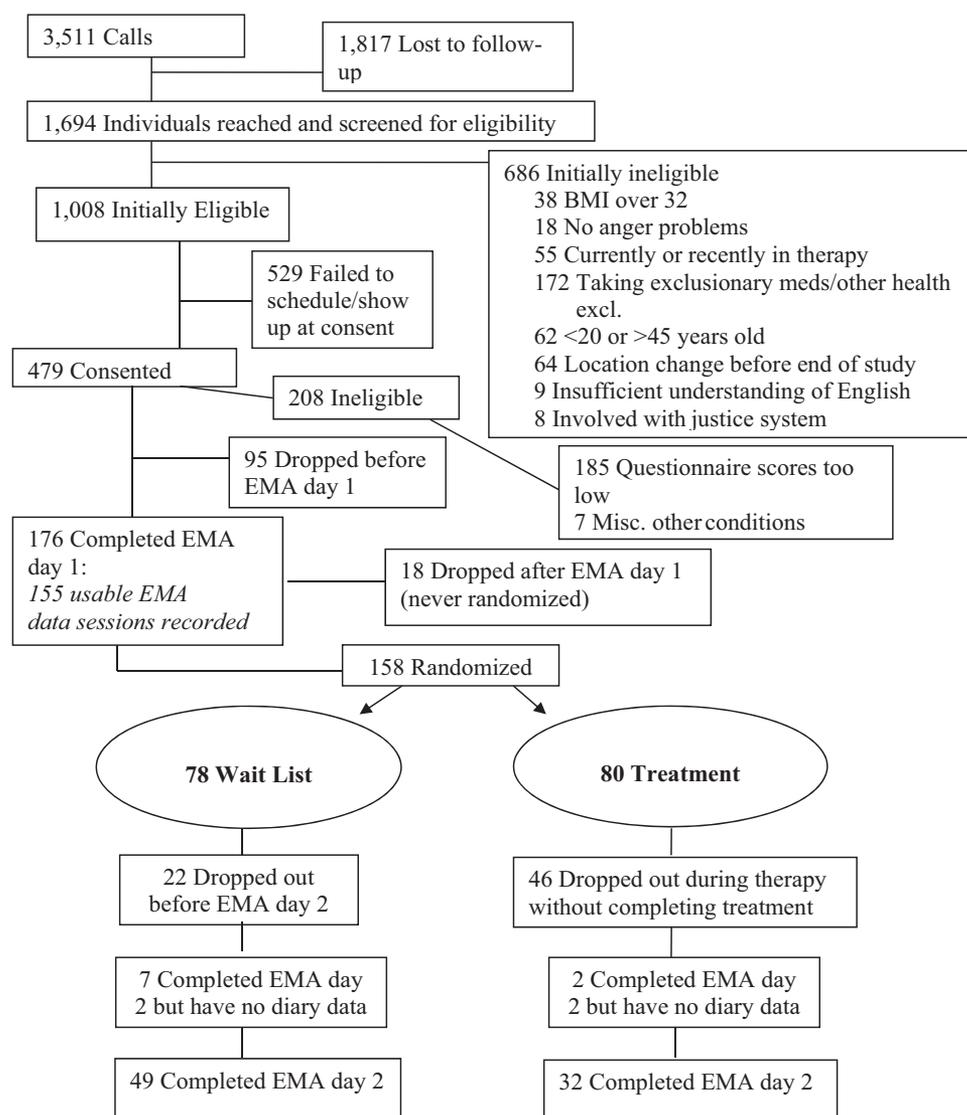


Figure 1. CONSORT participant flow diagram. EMA = ecological momentary assessment.

considered inappropriate were referred for treatment elsewhere. Eligible participants reported long-standing anger issues that caused them significant distress in domestic, interpersonal, occupational, and/or public domains of daily life, without any past or current physical aggression or court referral to anger-management treatment (as intrinsic motivation for treatment would be uncertain). In addition, they were not receiving any other psychological treatment or taking psychoactive medications. A typical participant's anger usually manifested as uncontrolled outbursts, or as a more contained internal experience with fewer outbursts.

## Experimental Protocol

Prior to randomization and again after the 12-week treatment period, participants completed 24 hr of electrocardiogram (ECG) monitoring to capture 24-hr heart-rate variability (HRV), which was the primary outcome of the study. The length of this monitoring period is a standard of care in clinical cardiology and the frequency of prompts is similar to other studies of momentary affect (Ebner-Priemer & Trull, 2009), which evidence suggests is sufficient to capture individual differences in NA states while still providing estimates that are robust against the mood effects of a particular day (Edmondson et al., 2013). Eligible participants reported to the laboratory at 8 a.m. on a weekday for baseline testing. Two ECG leads were attached to channels CM2 and CM5 of the Marquette 8500 ECG recorder (Marquette Electronics Inc., Milwaukee, WI), after which participants completed a laboratory mental stress-task protocol described elsewhere (Sloan et al., 2010). After the laboratory study and until the following morning, participants resumed their regular daily activities while continuing with ECG recording and carrying a preprogrammed Palm III personal digital assistant (PDA; Palm, Inc., Sunnyvale, CA). The PDA was programmed to beep every  $20 \pm 5$  min between 8:15am and 11:00 p.m., and participants began responding to prompts after the conclusion of their laboratory session until initiation of sleep. Each prompt presented a brief series of questions about stress and NA and responses were entered into the PDA.

Upon the completion of 24 hr of monitoring, participants returned the ECG recorder and PDA by mail, and after receipt of equipment by the research team, were randomized to either a wait-list control group or active CBT anger-reduction treatment. After completion of 12 weeks of treatment sessions or being on the wait-list, participants returned for EMA Day-2 testing and completed another 24-hr ECG monitoring with diary-data collection from the PDA. After this second session, wait-list participants began treatment. EMA Day-3 laboratory testing and 24-hr ECG monitoring were conducted as a 6-month posttreatment follow-up for the treatment group, and immediately after completing treatment for the wait-list group. Participants received monetary compensation for each EMA day they completed. Here, we report the results of the PDA diary-data collection at EMA Day 1 and Day 2. Data-collection staff members were blind to randomization group.

## Measurement of Stressors and NA

At each EMA prompt, participants reported exposure to stressors since last prompt, ratings of current NA, and responses to other questions about activity, location, physical position, and social interaction. The questions about stressful events began with

a frequency count of stressors since last beep ("Since last beep, how many stressful events?"), whether a stress event was "current," ("The MOST stressful event since the last beep: How long ago was it?") and whether the most stressful event was interpersonal or not. Regarding measurements of NA, participants were asked to estimate how "irritated or annoyed," "nervous or anxious," and "sad or disappointed" they felt "right now" on a 7-point Likert scale (with 0 = *not at all* and 6 = *very*) and NA at each prompt time was operationalized as a sum of responses to those three diary items for an NA sum range of 0–18. Other affect items also assessed but not included in the current hypotheses were "happy," "relaxed," "tired or drained," and "alert or energetic," as the present analysis focused only on those items measuring negative valence that have shown strong positive correlations with each other in the stress-reactivity literature (Crawford & Henry, 2004). Similar to "irritable" in the PANAS (Watson et al., 1988), the milder language of "irritated or annoyed" was chosen to represent momentary anger in the diary to facilitate participants' attending to angry feelings across a continuum from mild to extreme rather than only the more intense or obvious expressions of anger. There was high internal consistency for NA between these three diary items at EMA Day 1 (Cronbach's  $\alpha = .77$ ) and EMA Day 2 (Cronbach's  $\alpha = .83$ ). Following the approach of Sliwinski, Almeida, Smyth, and Stawski (2009), we operationalized NA reactivity to stressors as the numeric rating of the composite NA during episodes when a stressor was reported compared with the level of NA when no stressor was reported.

## CBT Treatment

The purpose of the CBT intervention was to reduce the amount of time patients spent experiencing anger on a daily basis. Participants met with one of three clinicians (Ethan Gorenstein, Catherine Monk, or Felice Tager) individually for 45–60 min, once a week, for 12 consecutive weeks. The manualized treatment developed by Drs. Gorenstein and Tager follows an exposure-based counterconditioning model in which participants are coached to apply cognitive, physical, and behavioral skills to decrease angry reactions to anger-provoking events (Gorenstein, Tager, Shapiro, Monk, & Sloan, 2007). An anger event was defined as having three components: (a) a triggering event, (b) the person's internal reaction to the event (including cognitive appraisal of the event and physiological arousal), and (c) a behavioral or verbal response. Treatment components included (a) psychoeducation on the conceptual model of persistent anger, (b) self-monitoring of significant angry feelings, (c) cognitive restructuring of thoughts reported in self-monitoring logs, (d) behavior therapy (including social and communication-skills training, and problem-solving training), (e) relaxation combined with visualized exposure to anger-provoking situations in session, and (f) in vivo exposure (i.e., contrived exposure to anger-provoking situations in daily life combined with application of cognitive-behavioral skills). The session-by-session treatment was delivered as a complete sequence of these six components while allowing clinicians to use their judgment in placing emphasis on certain components over others, depending on the individual needs of each participant. Participants assigned to the control group were placed on a 12-week waiting list for treatment, after which they received the same CBT treatment as the intervention group.

**Statistical Analysis**

Differences between treatment groups in demographic characteristics at baseline and differences in dropout were assessed using *t* tests for continuous variables and  $\chi^2$  tests for categorical variables.

A longitudinal model using a generalized estimating equation was designed to examine whether stressor exposure and affective reactions to momentary stressors changed from pre- to posttreatment in the CBT group. The longitudinal model was run on all randomized participants, included effects of the treatment group compared with the wait-list group, ambulatory NA and stressor assessment (EMA Day 2 compared with EMA Day 1), stressor (current stressor compared with no stressor), all of their two-way interactions (Group  $\times$  EMA Day, Group  $\times$  Stressor, EMA Day  $\times$  Stressor) and their three-way interaction (Group  $\times$  EMA Day  $\times$  Stressor). The longitudinal model controlled for age, sex, ethnicity, and baseline trait anger. Prespecified contrasts, which were to be explored only if the three-way interaction was significant, were included to estimate effects of stressor and treatment in relation to the hypotheses of interest. Cohen’s *d* effect sizes were computed using *F*-test statistics for prespecified contrasts, where 0.2 is a small effect, 0.5 is a moderate effect, and 0.8 is a large effect (Cohen, 1988; Thalheimer & Cook, 2002).

Analyses were done in SAS Version 9.4 using PROC GLIMMIX. All statistical tests were two-sided with significance level of 5%. To run longitudinal models in SAS, complete data are not required, and even the model that analyzes incomplete data provides unbiased results under the assumption that unobserved values are missing at random (Little & Rubin, 2002). Our analysis of dropout across groups and within the CBT group showed no significant association with demographic characteristics, trait anger, trait hostility, stressor frequency, or NA at baseline. Thus, missing data could be assumed to be missing at random and their analysis was expected to lead to unbiased estimates.

**Results**

Demographic information appears in Table 1. One hundred fifty-eight participants were randomized to either the CBT (*n* = 80) or wait-list (*n* = 78) groups. At baseline, the groups did not differ on age, sex, ethnicity, trait anger, or trait hostility (all *p* values > 0.05). The primary analysis indicated that randomization

to the treatment group was associated with a significant reduction in trait-anger scores relative to baseline ( $-1.071 \pm 0.286$ , *p* < .001; Sloan et al., 2010).

**Dropout Analysis**

A total of 90 participants completed EMA Day 2 (CBT *n* = 34, wait-list *n* = 56), but because of nine cases of PDA equipment failure, 81 of those participants provided EMA data for both baseline and follow-up assessments (CBT *n* = 32, wait-list *n* = 49; see Figure 1). Dropouts were defined as participants who exited the study before completion of treatment or 12 weeks of waiting without completing EMA Day 2; there were no participants who exited the study prematurely and still provided EMA Day-2 data. No significant differences were found between those who dropped out and those who completed the protocol on sex, age, ethnicity, or baseline Trait Anger or Hostility scale scores across both groups, though rates of dropout before follow-up testing were significantly higher for those randomized to the CBT group (60% vs. 37%;  $\chi^2(1) = 8.23$ , *p* < .01). In addition, across both groups, there were no significant differences in baseline momentary NA (*b* =  $-0.37$ , *SE* = 0.73, *p* = .62) or in the likelihood of reporting a stressful event (*b* = 0.082, *SE* = 0.34, *p* = .81) between those who completed the study and those who dropped out. Among members of the CBT group only, there were also no significant differences between dropouts and completers on any of these demographic factors or baseline Trait Anger or Hostility scores.

**EMA Hypotheses**

Participants completed a total of 7,186 diary entries across the two EMA monitoring days. The average number of diary prompts each participant completed was 30.20 (*SD* = 5.88) on EMA Day 1 and 30.18 (*SD* = 5.20) on EMA Day 2. Among those in the CBT group, 87.34% (69 of 79) of participants had at least one missing NA value at EMA Day 1, with a median compliance rate of 86.36%, and 90.63% (29 of 32) had at least one missing NA value at EMA Day 2, with a median compliance rate of 84.50%. Among those in the wait-list group, 84.21% (64 of 76) had at least one missing NA value at EMA Day 1, with a median compliance rate of 86.75%, and 84.31% (43 of 51) had at least one missing NA value at EMA Day 2, with a median compliance rate of 84.85%.

Table 1  
Prerandomization Participant Demographics

Characteristic	CBT ( <i>n</i> = 80) Mean $\pm$ <i>SD</i> or <i>n</i> (%)	Wait-list ( <i>n</i> = 78) Mean $\pm$ <i>SD</i> or <i>n</i> (%)	<i>p</i> value
Sex (female)	42 (52.5%)	42 (53.85%)	.87
Age (years)	30.64 $\pm$ 6.70	30.91 $\pm$ 6.77	.80
Ethnic origin			.64
Asian/Pacific Islander	5 (6.25%)	9 (11.54%)	
Black, Non-Hispanic	14 (17.50%)	16 (20.51%)	
Hispanic	18 (22.50%)	18 (23.08%)	
White, Non-Hispanic	41 (51.25%)	32 (41.03%)	
Native American, other or unknown	2 (2.50%)	3 (3.85%)	
Trait anger	30.80 (4.66)	30.69 (3.85)	.87
Trait hostility	32.71 (5.78)	32.72 (5.37)	.99

Note. CBT = cognitive-behavioral therapy.

There were no group differences in the proportion of completers or the compliance rate between groups at either EMA day ( $p > .05$ ). Descriptive statistics for NA ratings across groups, EMA days, and stressor versus nonstressor moments appear in Table 2 and Figure 2. Participants were more likely to report current stressors on the first EMA day than on the second ( $OR = 0.58$ , 95% CI = [0.4, 0.77],  $p < .001$ ), which did not differ across treatment conditions ( $p = .60$ ).

Table 3 presents the results and computed effect sizes of the prespecified contrasts for the EMA model. The significant three-way interaction ( $t_{28} = 2.29$ ,  $p = .030$ , Cohen's  $d = .37$ ) between stressor, treatment group, and EMA day indicates a differential effect of stressor on NA from EMA Day 1 to Day 2 between the treatment and wait-list groups. The effect size for this interaction was found to exceed Cohen's (1988) convention for a small effect ( $d = .2$ ).

### NA During Stressor Moments

The first hypothesis proposed that that NA on a 0–6-point Likert scale would be higher during current stressor moments than nonstressor moments within each treatment group and at each EMA day. For CBT participants on the first EMA day, NA was significantly higher (by 4.15 points, representing 91.67% higher NA) during current stressor moments than nonstressor moments, and at the second EMA day, NA was significantly higher (by 2.97 points, representing 76.44% higher NA) during current stressor moments compared with nonstressor moments (both  $p < .001$ ). For participants randomized into the wait-list group on the first EMA day, NA was significantly higher (by 3.39 points, representing 71.00% higher NA) during current stressor moments than nonstressor moments, and on the second EMA day NA was also significantly higher (by 3.81 points, representing 82.23% higher NA) during current stressor moments than nonstressor moments (both  $p < .001$ ).

### Treatment Effect on NA During Stressor Moments

The second hypothesis proposed that NA during stressors would be lower on EMA Day 2 for the treatment, but not the wait-list group. NA was significantly lower (by 1.6 points, 18.88% lower NA) for those undergoing CBT treatment than those randomized into the wait-list group ( $p = .034$ ).

Table 2

Mean Negative Affect During No-stressor and Stressor Moments for Each Group on Each EMA Day

	CBT EMA day 1	CBT EMA day 2	Wait-list EMA day 1	Wait-list EMA day 2
Moment	Mean $\pm$ SE	Mean $\pm$ SE	Mean $\pm$ SE	Mean $\pm$ SE
Current stressor	8.67 (.38)	6.85 (.55)	8.17 (.36)	8.45 (.46)
No stressor	4.53 (.28)	3.88 (.30)	4.78 (.29)	4.64 (.29)

Note. CBT = cognitive-behavioral therapy; EMA = ecological momentary assessment.

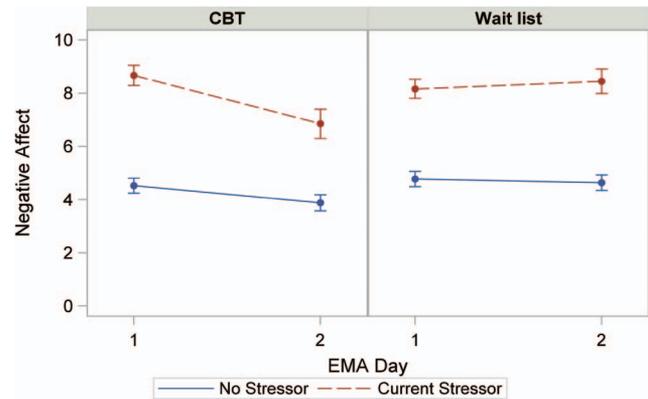


Figure 2. Negative affect (NA) model-adjusted means by treatment group during moments with and without reported current stressors. CBT = cognitive-behavioral therapy. See the online article for the color version of this figure.

### Treatment Effect on NA Reactivity During Stressor Moments

The third hypothesis proposed that NA reactivity to stressors would decrease at EMA Day 2 relative to EMA Day 1 for the treatment group. During current stressor moments compared with nonstressor moments, CBT participants had significantly lower NA (by 1.18 points, representing 28.42% lower NA) on EMA Day 2 than EMA Day 1 ( $p = .04$ ). In contrast, during current stressor moments compared with nonstressor moments, wait-list participants showed a nonsignificant change of 0.42 points (12.45%) on EMA Day 2 than EMA Day 1 ( $p = .34$ ). The difference in changes in NA from EMA Day 1 to EMA Day 2 between participants randomized to the CBT or wait-list group was estimated by the three-way interaction and its significance: The CBT-treatment group had a 1.60-point greater decrease in reactivity than the wait-list group ( $p = .03$ ).

### Differential Dropout Sensitivity Analysis

To assess potential bias of the findings resulting from differential dropout between treatment groups, we reanalyzed the data using a conservative approach, assuming the worst-case scenario for missingness (replacing CBT-group participants missing EMA Day 2 values with wait-list participants with complete data). We computed what the overall findings would have been if participants from the CBT group with missing EMA Day 2 data behaved similarly to participants in the wait-list group who received no treatment, but completed EMA Day 2 measurements. That is, we simulated that they had no effect of treatment at all. To reanalyze the data under this worst-case scenario, we used a technique similar to bootstrapping in which we randomly selected 18 wait-list participants with replacement who completed all observations to substitute 18 randomly selected CBT participants that were missing EMA Day 2 observations. Sampling with replacement means that if a wait-list participant was selected to substitute the first CBT participant that was missing EMA Day 2, the same wait-list participant could be again randomly selected to substitute the next CBT participant that was missing EMA Day 2. All

Table 3  
Model-Estimated Effects of Prespecified Contrasts Predicting Negative Affect

Contrasts	Prespecified simple-effects estimates					Cohen's <i>d</i> effect size
	Estimate	<i>SE</i>	<i>df</i>	<i>t</i>	<i>p</i> value	
3-way interaction (CBT × Stressor × EMA day)	1.60	.70	28	2.29	.03	.37
CBT only						
Current vs. no stressor, EMA Day 2 vs. EMA Day 1	−1.18	.55	28	−2.15	.04	.34
EMA Day 1, current vs. no stressor	4.15	.27	28	15.65	<.001	2.51
EMA Day 2, current vs. no stressor	2.97	.48	28	6.18	<.001	.99
Wait-list only						
Current vs. no stressor, EMA Day 2 vs. EMA Day 1	.42	.44	28	.97	.34	.16
EMA Day 1, current vs. no stressor	3.39	.24	28	14.32	<.001	2.29
EMA Day 2, current vs. no stressor	3.81	.37	28	10.34	<.001	1.66
Additional contrasts						
Current stressor at EMA Day 2, treatment vs. wait-list	−1.56	.71	28	−2.23	.034	.36

Note. CBT = cognitive-behavioral therapy; EMA = ecological momentary assessment.

wait-list participants are always available to substitute each CBT participant. This way, the independence of substituted subjects can be guaranteed. Adding these 18 wait-list participants to the CBT group balanced the dropout rates in both groups to approximately 37%. We then conducted the primary analysis on this new dataset and did so 500 times, each time randomly selecting 18 wait-list participants with complete data.

Of the 500 simulations, the median *p* value for the three-way interaction between stressor, treatment group, and EMA day was 0.12 with an interquartile range (IQR) between .045 and .304. For 26% of the simulations, the *p* value was below the 5% level and for 44% of the simulations the *p* value was below the 10% level. This means that even when heavily biasing ourselves against finding a significant three-way interaction by replacing 18 CBT participants with 18 wait-list participants, we still saw at least a trend level of significance almost half of the time. This analysis suggests that the significant Treatment Group × EMA Day × Stressor interaction was not the result of differential treatment-group dropout.

### Discussion

In this randomized controlled trial, participants high in Trait Anger and trait hostility in a CBT-intervention group that significantly decreased Trait Anger, NA measured in daily life was significantly higher during moments when participants reported current stressors, than in moments with no stressors. In addition, the 12-week CBT-treatment condition (compared with the wait-list condition) was associated with significantly lower NA when current stressors were reported, as well as significantly lower NA Stress Reactivity. Other EMA studies have found similar positive associations between daily stress and NA in nonclinical populations (Mroczek & Almeida, 2004; Sliwinski et al., 2009; Stawski, Sliwinski, Almeida, & Smyth, 2008). However, these field observations are unique because in addition to providing observations of NA reactivity to stressors in a clinical population at higher risk for negative health outcomes (Pimple et al., 2015; Smith & MacKenzie, 2006), the current analyses also evaluate the effects of a treatment to decrease the trait-like clinical presentation of one specific negative emotion, anger, on momentary NA Stress Reactivity.

To explore why a treatment to reduce chronic anger, but not to improve stress management per se, could nonetheless be associated with lower NA during stressors, it is useful to revisit cognitive models of each of the two constructs: Stress Reactivity and Trait Anger. The transactional stress appraisal model (Folkman, Lazarus, Dunkel-Schetter, DeLongis, & Gruen, 1986) theorizes Stress Reactivity as a two-step process in which an individual first makes a primary cognitive appraisal of the extent to which an internal or external agent threatens his or her well-being, followed by a secondary appraisal of available coping resources (Folkman et al., 1986). For individuals with high levels of chronic anger, primary appraisals are biased toward hostile interpretations of situational input such that difficult interactions with other people and daily hassles are immediately appraised as personally targeting the individual Wilkowski and Robinson (2010). Examples of primary appraisals of daily challenges from participants in the current study included that others were “deliberately trying to get on my nerves,” “out to get me,” and “ignoring me on purpose.”

The cognitive model of anger and reactive aggression further elucidates our understanding of what may happen during secondary appraisal for an individual high in Trait Anger (Wilkowski & Robinson, 2010). Once a provocation is encountered, the ruminative attention style of chronic anger prolongs cognitive contact with the incident through repetitive thoughts, often leading to an amplification of emotional intensity and greater duration of emotional response (Wilkowski & Robinson, 2007). From this heightened level of emotional activation, it becomes more difficult for an individual to recruit the effortful control that would allow him or her to interrupt rumination and suppress reactive aggression tendencies in favor of more effective behavior choices (Wilkowski & Robinson, 2007).

The targets of cognitive-behavioral anger-reduction treatment are thus twofold: cognitive reframing strategies to generate more balanced primary interpretations of anger provocations, and the learning and rehearsal of new coping strategies participants can use when anger is triggered. Participants' responses when asked to “indicate an alternative, more balanced interpretation of the . . . event that triggered an emotional reaction” suggest possible mechanisms by which CBT treat-

ment could have contributed to lower NA reactivity. For example, the stressor of almost being hit by a cyclist was reframed from “he was trying to hit me” to “he’s just not paying attention.” Similarly, the appraisal that “this person is ignoring my email” was reframed as “this person might be on vacation and may not have received my email;” a less personalized explanation that is more likely to lead to problem-solving behavior, such as resending the e-mail or making a follow-up phone call.

In regard to secondary appraisal of coping choices, some behavioral examples of improved effortful control reported by participants included “Went into another room to calm down,” “did some deep breathing,” “tried to put myself in her shoes,” “went on with my day,” and “spoke calmly instead of yelling.” The specific coping skills taught as part of the intervention (such as relaxation, communication skills, and problem solving) generally aid in the regulation of many states of NA in general and anger in particular (Gross & Thompson, 2007) so it is possible that a skills-generalization effect across different kinds of NA may account for the current findings.

The current study had several limitations. Because the strength of a randomized controlled trial design lies in its comparison condition, the choice of a wait-list control introduced specific limitations for the evaluation of psychotherapy interventions (Furukawa et al., 2014; Mohr et al., 2009). These limitations include (a) possible inflation of intervention effect sizes if the intervention target worsens in the control group during the wait-list period, and (b) the possibility of increased dropout as well as lack of equivalence in reasons for dropout between the two conditions (Mohr et al., 2009). Participants assigned to the wait-list condition in this study were made aware that they would receive the treatment after 12 weeks, however it remains unknown what factors contributed to the high rate of attrition seen in both groups (and especially the intervention group). The present analyses have not uncovered any significant differences between baseline randomization-group characteristics or those who completed the protocol compared with those who did not, and a conservative post hoc sensitivity analysis of differential dropout between the groups yielded a persistent effect of treatment on Stressor Reactivity. It remains possible that participants found the protocol too burdensome or experienced fluctuations in their motivation to change over the course of the intervention, though the intervention’s negative association with NA Stress Reactivity is nonetheless clinically promising in this at-risk population. Taking these limitations into account, future studies of CBT for high Trait Anger should include an active, structured control activity (such as supportive psychotherapy) as well as consideration of the participant burden of completing both a 12-week course of CBT and two ambulatory monitoring appointments. In addition, building task-analysis questions (Greenberg, 2007) or measures of behavior into the EMA diary could shed additional light on how learning from therapy sessions may be translating into participants’ daily lives.

Generalizability of these results is limited to those with chronic anger who would self-select to enroll in outpatient treatment, indicating a certain level of readiness for change. Motivation to engage in treatment and effectiveness of the treatment techniques offered in this study might differ for patients legally mandated to receive treatment, or individuals for whom physical aggression is an additional presenting con-

cern. The current participants were all drawn from a single major metropolitan area, which may be skewed toward high daily experience of current stress moments. Assessing a more specific description of stressors (e.g., using the Daily Inventory of Stressful Events; Almeida, Wethington, & Kessler, 2002) could offer insight into whether associations of NA with stress vary depending on stressor type.

As Folkman et al. (1986) emphasized in the transactional model, exposure to stress agents and availability of coping resources are subject to moment-to-moment fluctuations and are highly informed by one’s environmental and interpersonal context, and lend themselves to momentary assessment methods. Though stress exposure cannot always be controlled, CBT, in its aim to help patients build available coping skills for challenging stressful moments, may offer a unique clinical contribution to lowering NA reactivity and its associated risk.

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