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Changing Emotion Dynamics: Individual Differences in the Effect of Anticipatory Social Stress on Emotional Inertia

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Emotional inertia—the degree to which people's feelings carry over from one moment to the next—is an important property of the temporal dynamics of emotions. Thus far, emotional inertia has only been examined as a stable, trait-like characteristic. However, internal or external events (e.g., stress) may trigger changes in people's emotion dynamics, particularly among individuals with heightened sensitivity to such events. The current study investigated how emotional inertia is influenced by the anticipation of social stress, and how this effect is moderated by individual differences in depression, self-esteem, and fear of negative evaluation. We measured participants' (n = 71) emotional inertia in daily life using experience sampling before and after experimentally manipulating anticipatory social stress. Consistent with previous research, psychological maladjustment was associated with higher emotional inertia during "normal" daily life. However, when anticipating a socially stressful event, levels of emotional inertia dropped, particularly among participants scoring high on depression and fear of negative evaluation and low on self-esteem. These results demonstrate that emotion dynamics can vary as a function of contextual factors and identify moderators of such variation.

Keywords: emotion dynamics, emotional inertia, social stress, social-evaluative threat, depression, fear of negative evaluation, self-esteem

People differ dramatically in how their feelings change throughout daily life. Some people experience relatively few fluctuations in their emotions, remaining largely unperturbed by life's slings and arrows. Others may frequently become upset by minor, seemingly insignificant hassles. These observations fit with recent views of emotions as dynamic processes, subject to large individual differences (Davidson, 1998; Frijda, 2009; Kuppens, Stouten, & Mesquita, 2009; Scherer, 2009). Understanding how individuals differ in the dynamics of their emotional experiences is central to developing a comprehensive theory of emotions (Kuppens et al., 2009). However, it also has practical utility because the changes in people's feelings over time offer a unique window into their psychological functioning and well-being (Bylsma & Rottenberg, 2011; Myin-Germeys et al., 2009). The dynamical patterns in people's feelings across time are often considered to be stable, trait-like characteristics (e.g., Eid & Diener, 1999). Perhaps as a result, research has so far neglected the possibility that emotion dynamics may themselves change under certain conditions. This represents a notable gap in our knowledge about daily emotional functioning. The current study aimed to fill this gap by examining how emotion dynamics in daily life change when anticipating a social stressor and how such changes are moderated by individual differences.[1]

Emotion Dynamics

Researchers have come to distinguish between two important and distinct facets of emotion dynamics: *variability* and *temporal dependency* (Eaton & Funder, 2001; Jahng, Wood, & Trull, 2008; Larsen, 1987). Variability is often represented by the within-person standard deviation of a feeling over time (e.g., Eid & Diener, 1999) and reflects how much people's emotional experiences deviate from their average feelings. Affective variability has been studied extensively and has known correlates, such as neuroticism (Murray, Allen, & Trinder, 2002), low self-esteem (Kuppens, Van Mechelen, Nezlek, Dossche, & Timmermans, 2007), depression (McConville & Cooper, 1996; Hall, Sing, & Romanowski, 1991), borderline personality disorder (BPD; Stein, 1996), and bipolar disorder (Knowles et al., 2007).

The degree to which people's feelings display temporal dependency can be thought of as their level of *emotional inertia* (Kuppens, Allen, & Sheeber., 2010; Suls, Green, & Hillis, 1998).

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[1] Emotions are generally viewed as multicomponential processes involving physiology, cognition, motivation, behavior, and subjective conscious experience (Scherer, 2009). The current research focused exclusively on the last of these components, which we refer to as *feelings* or *emotional experiences*. However, we also use the general term *emotion dynamics* to refer to patterns of changes and fluctuations in a person's feelings over time.

Emotional inertia can be operationalized as the autocorrelation of an emotion (i.e., the correlation of a person's current feeling with their feeling at the previous time point).[2] Thus, emotional inertia represents how much a person's feelings carry over from one moment to the next, with higher levels indicating "resistance to emotional change" (Kuppens, Allen, & Sheeber, 2010, p.985). Research examining emotional inertia is relatively scarce in comparison with studies of emotional variability. However, recent findings suggest that the temporal dependency of people's feelings may reveal crucial information about their emotional functioning, independent of their level of emotional variability (Kuppens, Allen, & Sheeber, 2010). For instance, higher emotional inertia has been linked to markers of maladjustment such as neuroticism (Suls et al., 1998), anorexia nervosa (Stein, 1996), depression, and low self-esteem (Kuppens, Allen, & Sheeber, 2010), and may even represent a vulnerability factor for the development of depression in adolescence (Kuppens et al., 2011). The current study therefore focused on this important, yet neglected, aspect of emotion dynamics.

Although the findings mentioned above point to the maladaptive nature of high inertia, it stands to reason that the opposite extreme—very low emotional inertia—may not be very adaptive either. Indeed, extremely low emotional inertia would be indicative of rapidly changing emotional experiences and may indicate aberrant emotional responding and/or emotional dysregulation. For instance, Tolpin, Gunthert, Cohen, and O'Neill (2004) found that people with more features of BPD displayed lower inertia for negative emotions and self-esteem, compared with those with fewer BPD features. Thus, exhibiting very low levels of emotional inertia may also reflect problematic emotional functioning.

Changing Emotion Dynamics

Most research on emotion dynamics has proceeded from the tacit assumption that emotion dynamics reflect stable, trait-like characteristics of the individual. The possibility that a person's emotion dynamics may vary as a function of contextual factors has therefore been largely overlooked. In contrast, a dynamical systems approach (e.g., Vallacher, Read, & Nowak, 2002; Witherington & Crichton, 2007) suggests that internal or external events may trigger changes in the operating characteristics of a person's emotion system, giving rise to a different set of dynamic properties (Hoeksma, Oosterlaan, Schipper, & Koot, 2007; Kuppens, Oravecz, & Tuerlinckx, 2010). Although a variety of factors could conceivably set off changes in a person's emotion dynamics, a highly plausible trigger is stress.

Stress is known to influence many facets of psychological and physiological functioning (Lupien, McEwen, Gunnar, & Heim, 2009), yet its impact on emotion dynamics has received little empirical attention. A notable exception is Zautra and colleagues' research on the influence of stress on the association between people's experiences of positive and negative affect over time (e.g., Reich, Zautra, & Davis, 2003; Zautra, Berkhof, & Nicolson, 2002). It remains to be seen whether stress also influences other aspects of emotion dynamics such as emotional inertia. The current study aimed to directly address this question.

Social Stress and Sensitivity to Social-Evaluative Threat

The degree to which stress can (temporarily) change a person's emotion dynamics may depend on the person's underlying vulnerability or sensitivity to the stressor in question. The current study focused on *social stress*: a frequent experience in daily life in which a person's social status, value, or esteem is threatened (Dickerson, 2008). Such situations are experienced as stressful by most people because they involve *social-evaluative threat* (Dickerson & Kemeny, 2004), which obstructs the fundamental human motive to maintain social acceptance and avoid exclusion (e.g., Baumeister & Leary, 1995; Bowlby, 1969; Maslow, 1987). Yet, a number of individual differences may predict how vulnerable people are to experiencing social-evaluative threat (Gruenewald, Dickerson, & Kemeny, 2007).

An obvious first candidate is *fear of negative evaluation* (FNE). People high in FNE tend to be preoccupied with how they are perceived and are motivated to avoid being judged negatively by others (Watson & Friend, 1969). For instance, high-FNE individuals allocate greater attentional and perceptual resources to socially threatening information (e.g., Mansell & Clark, 1999; Stopa & Clark, 2001; Winton, Clark, & Edelmann, 1995). Furthermore, FNE is closely related to social anxiety, which is itself a strong predictor of hypersensitivity to social-evaluative threat (Weeks et al., 2005). A second possible vulnerability factor is *self-esteem*. According to sociometer theory, self-esteem acts as an internal gauge of a person's social value, alerting the individual to any risk of social exclusion (Leary & Baumeister, 2000). As a consequence, people with low trait self-esteem (who believe that they are not held in high regard by others) display hypersensitivity to negative social evaluation (Murray, Holmes, & Collins, 2006). Finally, *depression* may also be considered to involve increased sensitivity to social-evaluative threat. Allen and Badcock (2003) have proposed that depressive states (evolved to) help defend against the threat of social exclusion by promoting avoidance of risky social behaviors and increasing vigilance to signs of social threat (see also Gilbert, 2006). In line with this view, a heightened concern with social evaluation is an important feature of depressive phenomenology (Gilbert, 1992), and depressive states are often preceded, or prolonged, by the experience of interpersonal

[2] An autocorrelation represents the temporal dependency in a person's feelings, however it does not capture the amplitude of these changes (i.e., the degree of variability in a person's feelings; Ebner-Priemer et al., 2007). Therefore, in the (rare) case that two people's emotions changed with equal frequency, but differed with respect to the size of emotional change, an autocorrelation would not fully capture these differences. As a result, some researchers have suggested that emotion dynamics should be measured using a single index that captures both variability (amplitude) and temporal dependency in people's feelings, such as the mean square successive difference (MSSD; Ebner-Priemer, Eid, Kleindienst, Stabenow, & Trull, 2009; Jahng et al., 2008). However, variability and temporal dependency can be thought of as conceptually independent aspects of emotion dynamics (Larsen, 1987), and it may therefore be informative to examine each separately. In particular, recent research suggests that the temporal dependency (i.e., emotional inertia) of people's feelings may represent an important, yet neglected, component of emotional functioning in its own right (Kuppens, Allen, & Sheeber, 2010). We therefore focused exclusively on this aspect of emotion dynamics in the current study.

loss or rejection (Allen & Knight, 2005). Throughout this article, we refer to high depression, high FNE, and low self-esteem collectively as "sensitivity to social-evaluative threat."

Sensitivity to social-evaluative threat is also likely to be associated with broader dispositions such as rejection-sensitivity (Downey & Feldman, 1996) and ego-resiliency (Block & Kremen, 1996). Interestingly, resilient individuals may not differ from those with increased vulnerabilities (e.g., sensitivity to social-evaluative threat) in the intensity of their emotional reactions to stressors (Tugade & Fredrickson, 2004). For instance, stronger affective responses to social stressors are not consistently observed among people with low self-esteem (e.g., Ford & Collins, 2010; see also Baumeister, Campbell, Krueger, & Vohs, 2003) or among depressed individuals (Burke, Davis, Otte, Mohr, 2005). Rather, what appears to distinguish the resilient from the vulnerable is their ability to effectively regulate negative emotions under stress (Waugh, Fredrickson, & Taylor, 2008). The degree to which people are able to successfully regulate their emotions would be reflected in their emotional inertia levels (Kuppens, Allen, & Sheeber, 2010; Suls & Martin, 2005). High levels of inertia reflect the persistence of an emotion over a long period of time, whereas low levels indicate frequent emotional changes, both of which may result from ineffective emotion regulation.

Overview of the Current Study

The purpose of the current study was to investigate whether three factors associated with sensitivity to social-evaluative threat (depression, low self-esteem and FNE) predict changes in emotional inertia under anticipatory social stress. At a within-person level, we repeatedly measured participants' feelings of anxiety and stress as they naturally occurred in daily life using the experience sampling method (ESM; Csikszentmihalyi & Larsen, 1987), both before and after an experimental manipulation of anticipatory social stress. This allowed us to compare participants' emotional inertia during a "normal" period in daily life with their emotional inertia when anticipating a socially stressful event in daily life. At a between-person level, we examined how individual differences in sensitivity to social-evaluative threat were related to intraindividual changes in emotional inertia as a function of anticipatory social stress.

As outlined above, we conceptualize sensitivity to social-evaluative threat as a specific vulnerability to being negatively evaluated by others. However, given our focus on how this vulnerability influences people's experiences of negative feelings in daily life, it is important to distinguish sensitivity to social-evaluative threat from a general tendency to experience negative emotions (i.e., negative affectivity). We therefore also measured positive and negative affectivity (Watson, Clark & Tellegen, 1988), and additionally performed all analyses controlling for individual differences in these emotional traits.

We focused on anticipatory stress for two reasons. First, future expectations are an important feature of many psychological stressors (Folkman & Lazarus, 1985; Lupien et al., 2009), and they can elicit similar emotional and physiological stress responses as stressful events themselves (Gramer & Reitbauer, 2010; Waugh, Panage, Mendes, & Gotlib, 2010). Second, the anticipatory period may often last longer (e.g., hours or days) than the stressor itself. This made it possible for us to reliably measure emotion dynamics, which requires multiple assessments of emotions over time. We focused on feelings of anxiety and stress because these are primary examples of *threat emotions*, which are particularly relevant during the anticipatory period of a stressful encounter (Folkman & Lazarus, 1985; Feldman, Cohen, Hamrick, & Lepore, 2004).

We made two specific predictions. First, consistent with Kuppens, Allen, & Sheeber (2010), we predicted that higher levels of psychological maladjustment (i.e., higher depression and FNE, and lower self-esteem) would be associated with higher emotional inertia during normal daily life. Second, we predicted that anticipating a social stressor would trigger changes in people's emotion dynamics and thereby influence their levels of emotional inertia, particularly among more vulnerable individuals. In other words, we predicted that the effect of anticipatory social stress on emotional inertia would be moderated by individual differences in depression, self-esteem, and FNE. Either increases or decreases in emotional inertia under social stress are conceivable, depending on the processes underlying such changes. For instance, individuals with heightened sensitivity to social-evaluative threat may become increasingly emotionally disengaged when anticipating a social stressor to avoid the associated threat. Alternatively, more vulnerable people may experience an initial increase, followed by a sustained high level of threat emotions when facing an impending stressor. Either of these cases would result in an increase in emotional inertia under anticipatory social stress (cf. Kuppens, Allen, & Sheeber, 2010; Study 2). On the other hand, vulnerability to social stress may be associated with impairments in emotion regulation (e.g., Gross & Muñoz, 1995) and coping abilities (Taylor & Stanton, 2007). As a result, vulnerable individuals may fail to effectively down-regulate their threat emotions when anticipating a social stressor, resulting in a series of repeated increases and decreases (after regulation) in their feelings. This more erratic pattern of emotional changes would manifest itself as a decrease in their emotional inertia. Given the lack of previous research on this issue, the current study explored the direction of this predicted interaction.

Method

Participants

Seventy-nine participants were recruited by advertisement on a university website to complete the study in exchange for payment of AU$40. Participants with a current diagnosis of mental disorder were excluded at prescreening. Six participants withdrew early, and two participants with substantial (>40%) missing data were excluded from analyses, leaving a final sample of 71 people (41 females, 30 males) ranging in age from 18 to 35 years ($M = 20.82$, $SD = 2.88$). Most participants (90.2%) were university students from a variety of academic disciplines (e.g., natural sciences, humanities, social sciences, engineering, education, fine arts). The remaining participants (9.8%) were recent graduates.

Materials

Dispositional measures. Participants completed the 20-item Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977). The CES-D asks participants to rate how frequently they have experienced a range of depressive symptoms (e.g., "I

had crying spells") over the past week on a four-point scale ranging from 0 (*rarely or none of the time*) to 3 (*most or all of the time*). The CES-D is a sensitive measure of individual differences in depression severity within student populations (Santor, Zuroff, Ramsay, Cervantes, & Palacios, 1995). Trait self-esteem was measured using the Rosenberg (1965) Self-Esteem scale (RSE). The RSE comprises 10 self-statements (e.g., "on the whole, I am satisfied with myself") rated on a four-point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Participants completed the Brief Fear of Negative Evaluation scale (B-FNE; Leary, 1983) comprising 12 statements regarding concerns with being judged negatively by others (e.g., "I am afraid that people will find fault with me"). Responses are made on a five-point scale ranging from 1 (*not at all characteristic of me*) to 5 (*extremely characteristic of me*). Trait positive affectivity (PA) and negative affectivity (NA) were measured using the two 10-item scales of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). Participants were asked to rate to what extent they generally experience each of the 10 positive feelings (e.g., "proud," "enthusiastic") and 10 negative feelings (e.g., "distressed," "upset") in their "normal daily life" on a scale from 1 (*very slightly or not at all*) to 5 (*extremely*). Intercorrelations, descriptive and reliability statistics for the dispositional measures are presented in Table 1.

ESM measures. An ESM questionnaire was displayed on Palm Tungsten E2 palmtop computers. At each sampling moment, or "beep", participants responded to several items measuring their current feelings, including two items that measured anxiety and stress ("at the moment, how anxious/stressed are you feeling?"). Responses were made using a continuous slider scale from 1 (*not at all anxious/stressed*) to 100 (*very anxious/stressed*). Item order was randomized at each beep.

Laboratory measure of current feelings. Participants reported their current feelings at four time points in the laboratory, by rating the extent to which they were feeling each of the following 12 adjectives: "worried", "anxious", "nervous" (*anxiety*); "under pressure", "stressed", "tense" (*stress*); "irritated", "angry", "pissed off" (*anger*); "cheerful", "happy", "in good spirits" (*happiness*). Responses were made using a 7-point scale from 1 (*not at all feeling this way*) to 7 (*very much feeling this way*). The six items measuring anxiety and stress were averaged to form an overall measure of "threat emotion" (all alphas at each time were $>.88$). Anger and happiness scales were formed by averaging responses to the three items measuring each feeling (all alphas at each time were $>.70$). Anger and happiness were included to assess whether our experimental manipulation selectively influenced threat emotions or had a more general effect on positive and negative feelings.

Manipulation of anticipatory social stress. Anticipatory social stress was manipulated by informing participants that they would complete the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). The TSST is a widely used lab paradigm for eliciting social stress (Kudielka, Hellhammer, & Kirschbaum, 2007; Dickerson & Kemeny, 2004). Participants were given a TSST instruction sheet, adapted from Kudielka et al. (2007), describing a public speaking task and mental arithmetic task that they would later complete. The instructions described the tasks as "difficult and demanding" and informed participants that "many people find the tasks to be quite trying, so it is important to prepare yourself." Participants also read that their "performance on these tasks will be judged by an evaluation committee consisting of experts in behavioral analysis" and that their performance would be video recorded. Finally, to increase uncertainty, participants were informed that they would receive more detailed instructions for the tasks at a later time.

Procedure

The study ran over two consecutive weekdays. On the first day, a baseline measure of participants' emotional experiences in daily life was obtained using ESM. On the second day, participants were instructed that they would be completing the TSST later that day (see above) and their feelings in daily life were measured using ESM while anticipating this impending social stressor. Figure 1 displays an overview of the study procedure.

Initial lab session. In an initial lab session on the morning of the first day (between 9 a.m. and 10 a.m.), participants provided informed consent for a study involving experience sampling and "lab tasks." Participants then reported basic demographic information, completed the dispositional measures, and rated their feelings at that moment on the 12 current feeling items (Time 1). Next, participants received detailed instructions for the ESM protocol, practiced responding to the ESM questionnaire on the palmtop, and had an opportunity to ask the experimenter clarification questions. Experience sampling began immediately after participants left the lab. Participants were naïve to the TSST until the second day of the study.

Table 1
Intercorrelations and Descriptive Statistics for Dispositional Measures

								Range		
Measure	1	2	3	4	5	*M*	*SD*	Possible	Actual	α
1. CES-D	—	**−.62**	**.55**	**.37**	**−.31**	14.52	8.28	0–60	0–42	.86
2. RSE		—	**−.51**	**−.32**	**.38**	30.04	4.99	10–40	18–40	.85
3. B-FNE			—	**.49**	−.19	36.15	9.38	12–60	16–59	.89
4. NA				—	−.18	17.17	4.52	10–50	11–36	.71
5. PA					—	32.90	6.73	10–50	15–46	.87

Note. Correlations significant at $p < .01$ are shown in boldface. $n = 71$ for all correlations. CES-D = Center for Epidemiological Studies Depression scale; RSE = Rosenberg Self-Esteem scale; B-FNE = Brief Fear of Negative Evaluation scale; NA = Negative Affectivity scale; PA = Positive Affectivity scale.

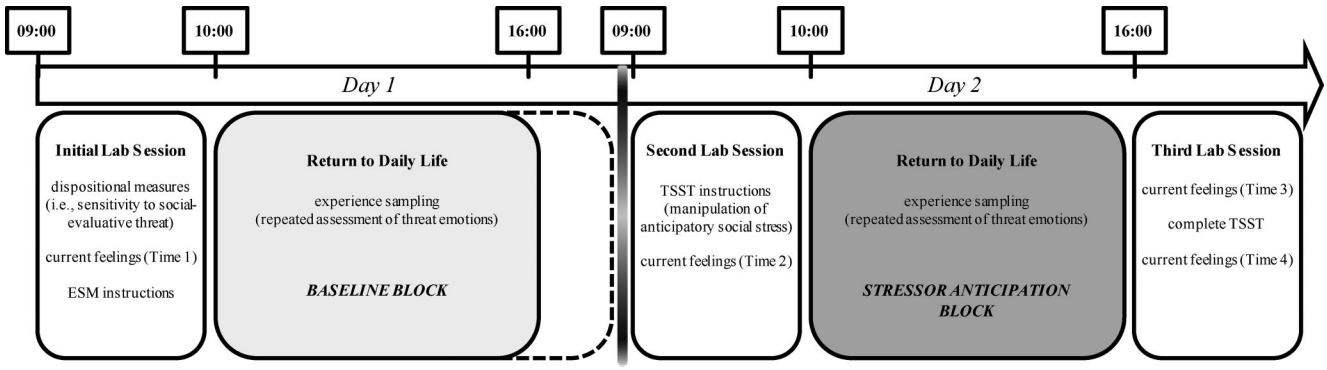

Figure 1. Overview of study procedure indicating Baseline and Stressor Anticipation blocks. All participants completed the study over two consecutive weekdays. Times shown are approximate because of slight variations in scheduling of the lab sessions for each participant. Baseline block is shaded in light gray; Stressor Anticipation block is shaded in dark gray.

ESM protocol. Participants carried the palmtop during their normal daily activities and responded to the ESM questionnaire when signaled over the two days of the study. The palmtops were programmed to beep 60 times per day starting from the end of the initial lab session (approximately 10 a.m.) for a period of 12 hours (until approximately 10 p.m.), according to a stratified random interval scheme: the day was divided into 60 equal intervals and one beep was programmed to occur randomly within each interval. The intensive sampling frequency allowed us to properly capture the temporal dynamics of emotions over a period of several hours (Ebner-Priemer & Sawitzki, 2007) and was necessary to calculate a reliable estimate of emotional inertia (i.e., autocorrelation). To minimize participant burden the number of questions at each beep was kept to a minimum, and participants were carefully prepared and motivated for the ESM data collection. Previous ESM studies have successfully used similarly intense sampling frequencies (Ebner-Priemer & Sawitzki, 2007; Kuppens, Oravecz, & Tuerlinckx, 2010). Despite the intense protocol, compliance was high: participants responded to 89.7% of the programmed beeps in total. Individual participants completed between 61% and 100% of their programmed beeps ($M = 89.9\%$, $SD = 9.0\%$). Furthermore, the proportion of missing beeps did not differ between the Baseline and Stressor Anticipation blocks ($p = .29$). Finally, compliance rates (both in total and in each block separately) did not significantly correlate with scores on any of the dispositional measures (all $ps > .30$).

TSST. Participants attended the lab again on the morning of the second day (between 9 a.m. and 10 a.m.) and were informed of the upcoming TSST (see above). After reading the TSST instructions, participants once again completed the 12 current feelings items (Time 2). Participants then left the lab, and the ESM data collection resumed. Individual sessions were scheduled for participants to come back between 3 p.m. and 5 p.m. that day to complete the TSST. Upon arrival for the afternoon session, participants completed the current feelings items (Time 3) and were escorted into a separate room to complete the TSST. Finally, after completing the TSST participants rated their current feelings once more (Time 4).

Data Analytic Strategy and Preliminary Analyses

To account for the hierarchical structure of the ESM data (i.e., beeps nested within participants) we adopted a multilevel modeling approach (e.g., Bryk & Raudenbush, 1992; Nezlek, 2001). This approach allowed us to examine within-person autocorrelations (representing emotional inertia) at Level-1, and their between-person relationships with sensitivity to social-evaluative threat at Level-2. Preliminary multilevel analyses indicated that the stress and anxiety items measured in the ESM were highly associated: predicting anxiety from stress, or vice versa, resulted in a 39.7% reduction in within-person error variance, corresponding to a multilevel correlation of .63 (see Nezlek, 2001). We therefore averaged scores on the anxiety and stress ESM items to form a composite "threat emotion" measure, which served as the dependent variable in our main analyses.

To examine how the anticipation of a social stressor influences emotion dynamics, we compared emotional inertia of threat emotions in two separate periods, or blocks, of the ESM data. The "Stressor Anticipation" block contained data on participants' feelings leading up to a socially stressful event (i.e., the TSST). Specifically, the Stressor Anticipation block began when participants received the TSST instructions (at approximately 10 a.m. on Day 2) and ended when participants arrived at the lab to complete the TSST (at approximately 4 p.m. on Day 2). The "Baseline" block consisted of the equivalent period on Day 1 (defined individually for each participant) and therefore comprised a control, or baseline, measure of participants' feelings in normal daily life. These data comprised 3914 beeps (1905 beeps during Baseline, 2009 beeps during Stressor Anticipation). On average, participants were beeped 27 times during the Baseline block and 28 times during the Stressor Anticipation block.

As a first step, each multilevel model was conducted with no Level-2 predictors to obtain average estimates of emotional inertia for the entire sample. The Level-1 coefficient estimates reported below were taken from these initial analyses with no Level-2

predictors.[3] Subsequently, standardized scores on the dispositional measures were entered as predictors at Level-2 to investigate the relationship between each measure and individual differences in emotional inertia. The Level-2 predictors were significantly intercorrelated (see Table 1) and were therefore analyzed in separate models.

Results

Manipulation Check

Scores on the laboratory measure of current feelings served as a manipulation check. Participants' experience of threat emotion increased significantly from Time 1 ($M = 2.53$, $SD = 1.26$) to Time 2 ($M = 3.20$, $SD = 1.37$), and increased significantly again at Time 3 ($M = 3.67$, $SD = 1.34$), followed by a significant decrease at Time 4 ($M = 3.16$, $SD = 1.47$) although they remained significantly higher than at Time 1 (all $ps < .02$ after Bonferroni adjustment). These findings indicate that the experimental manipulation of anticipatory social stress induced an increase in threat emotion in the laboratory. Notably, after the stressor had passed (Time 4), participants' threat emotions decreased again. Ratings of happiness and anger did not differ significantly from Time 1 to Time 3 (all $ps > .05$), indicating that these feelings were not similarly influenced by the experimental manipulation. However, there was a significant increase in anger and a significant decrease in happiness at Time 4, indicating that participants felt less happy and more angry immediately after completing the TSST ($ps < .05$). ANCOVAs controlling for CES-D, RSE and B-FNE scores revealed that the above effects were not significantly qualified by sensitivity to social-evaluative threat (all $ps > .05$).

Emotional Inertia During Baseline and Stressor Anticipation

A first series of models examined how sensitivity to social-evaluative threat was related to emotional inertia separately in the Stressor Anticipation and Baseline blocks.[4] Two dummy variables, "BSLN" (1 = Baseline block, 0 = Stressor Anticipation block) and "SA" (1 = Stressor Anticipation block, 0 = Baseline block), were used to obtain separate estimates of inertia in the Baseline and Stressor Anticipation blocks, respectively. The Level-1 equation was as follows:

$$threat_{ti} = \pi_{0i}(BSLN_{ti}) + \pi_{1i}(SA_{ti}) + \pi_{2i}(BSLN_{ti} * Threat_{t-1i}) + \pi_{3i}(SA_{ti} * Threat_{t-1i}) + e_{ti}$$

Here, $threat_{ti}$ denotes a particular person i's level of threat emotion at a particular time t. The random coefficients π_{oi} and π_{1i} represent person i's mean level of threat emotion during the Baseline and Stressor Anticipation blocks, respectively. The random slopes π_{2i} and π_{3i} are autocorrelation parameters representing the degree to which a person i's level of threat emotion at the previous time $t - 1$ predicts their current level of threat emotion during the Baseline and Anticipation blocks, respectively. These autocorrelation slopes are a direct operationalization of emotional inertia (Kuppens, Allen, & Sheeber, 2010). At Level-2, standardized CES-D, RSE, and B-FNE scores were used to predict variation across participants in the Level-1 random coefficients. For example, the Level-2 equations modeling the between-person effect of RSE are displayed below:

$$\pi_{0i} = \beta_{00} + \beta_{01}RSE_i + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}RSE_i + r_{1i}$$

$$\pi_{2i} = \beta_{20} + \beta_{21}RSE_i + r_{2i}$$

$$\pi_{3i} = \beta_{30} + \beta_{31}RSE_i + r_{3i}$$

Mean levels. As shown in Table 2, mean levels of threat emotion were significantly qualified by CES-D, B-FNE, and RSE scores in both blocks. Specifically, participants higher in sensitivity to social-evaluative threat experienced significantly higher levels of threat emotion during both Baseline and Stressor Anticipation (see left plots in Figure 2).

Emotional inertia. As predicted, sensitivity to social-evaluative threat was associated with significantly higher emotional inertia in the Baseline block (see autocorrelation slopes in Table 2). Thus, consistent with previous research (e.g., Kuppens, Allen, & Sheeber, 2010), psychological maladjustment was related to higher emotional inertia during normal daily life.[5] The pattern of findings was markedly different in the Stressor Anticipation block, however. The relationships between inertia and individual differences in sensitivity to social-evaluative threat trended in the opposite direction. The effect of CES-D significantly reversed, such that higher depression scores were associated with significantly lower emotional inertia under anticipatory social stress (see Table 2).

Changes in Emotional Inertia During Stressor Anticipation

The results reported above suggest that sensitivity to social-evaluative threat may be associated with larger changes in emotional inertia when anticipating a social stressor. To examine this possibility directly, we estimated models examining change in

[3] Level-1 coefficient estimates were almost identical, and their p values did not differ, when Level-2 predictors were included in the models.

[4] Preliminary analyses included time of day (at Level-1) and participant sex (at Level-2) as covariates in all multilevel models. Neither time of day nor participant sex had significant effects, and neither significantly qualified any other effects in the models. For parsimony, we report the results of models without these covariates.

[5] Although our focus in the current paper was on negative emotions (specifically, threat emotions), we also included measures of happiness and relaxation in the ESM questionnaire. Multilevel analyses using a composite "positive emotion" measure revealed that sensitivity to social-evaluative threat was associated with higher inertia of positive emotions during Baseline (all $ps < .04$), in line with our results for threat emotion and replicating previous findings (Kuppens, Allen, & Sheeber, 2010). However, sensitivity to social-evaluative threat was not consistently associated with greater decreases in inertia of positive emotions during Stressor Anticipation (ps ranged from .001 to .418). Separate analyses for happiness and relaxation revealed that the significant changes in inertia were driven largely by relaxation. Given that relaxation can be seen as the opposite of threat emotion (i.e., stress and anxiety), and correlated with threat emotion at –.53 in the current data, these results can be considered to be in line with the current study's main findings.

Table 2
Multi-Level Models Estimating Mean Levels and Autocorrelations Separately During Baseline and Stressor Anticipation, as a Function of Sensitivity to Social Evaluative Threat

		Level-1			Level-2							
						CES-D		RSE		B-FNE		
Outcome	Block	Effect	Parameter	β (*SE*)	*p*	Parameter	β (*SE*)	*p*	β (*SE*)	*p*	β (*SE*)	*p*
Threat emotion	Baseline	Mean level	β_{00}	28.09 (1.80)	<.001	β_{01}	6.41 (1.27)	<.001	−4.08 (1.68)	.018	5.05 (1.50)	.002
		Autocorrelation	β_{10}	0.44 (0.04)	<.001	β_{11}	0.07 (0.02)	.010	−0.09 (0.03)	.002	0.09 (0.03)	.006
	Stressor anticipation	Mean level	β_{20}	29.10 (2.00)	<.001	β_{21}	6.69 (1.56)	<.001	−4.62 (1.89)	.017	6.57 (1.80)	.001
		Autocorrelation	β_{30}	0.32 (0.03)	<.001	β_{31}	–0.05 (0.02)	.024	0.02 (0.03)	.435	−0.03 (0.03)	.263

Note. Level-1 lagged predictors used to calculate emotion autocorrelations were group-mean centered. Intercept and slope values at Level-1 were estimated in a model with no predictors at Level-2 (*df* = 70). Level-2 predictors were standardized and entered in separate models (*df* = 69); CES-D = Center for Epidemiological Studies Depression scale; RSE = Rosenberg Self-Esteem scale; B-FNE = Brief Fear of Negative Evaluation scale.

autocorrelation from Baseline to Stressor Anticipation as a function of CES-D, RSE, and B-FNE scores. The Level-1 equation was identical to the first, except that instead of estimating separate Level-1 random coefficients for the pre- and postmanipulation periods, we used a single dummy variable (SA) to represent changes in the intercept and slope from Baseline to Stressor Anticipation:

$$threat_{ti} = \pi_{0i} + \pi_{1i}(SA_{ti}) + \pi_{2i}(Threat_{t-1i}) + \pi_{3i}(SA_{ti} * Threat_{t-1i}) + e_{ti}$$

Here, the random coefficient π_{0i} represents a person *i*'s mean level of threat emotion during the Baseline block, whereas π_{1i} represents the change in that mean level from Baseline to Stressor Anticipation. The random slope π_{2i} represents the autocorrelation (inertia) of person *i*'s threat emotion during the Baseline block, whereas π_{3i} represents the change in that autocorrelation slope from Baseline to Stressor Anticipation. As in the first analyses, standardized CES-D, RSE, and B-FNE scores were used to predict variation across participants in the Level-1 random coefficients. For example, the Level-2 equations modeling the between-person effect of RSE are displayed below:

$$\pi_{0i} = \beta_{00} + \beta_{01}RSE_i + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{01}RSE_i + r_{1i}$$

$$\pi_{2i} = \beta_{20} + \beta_{21}RSE_i + r_{2i}$$

$$\pi_{3i} = \beta_{30} + \beta_{21}RSE_i + r_{3i}$$

Changes in mean levels. As shown in Table 3, the mean level of threat emotion did not change from Baseline to Stressor Anticipation. Furthermore, individual differences in sensitivity to social-evaluative threat were not significantly associated with changes in mean levels of threat emotion. To illustrate these findings, we computed separate slopes at one standard deviation above and below the mean scores of the sensitivity to social-evaluative threat measures (see left panel of Figure 2).

Changes in emotional inertia. In contrast to the findings for mean levels of threat emotion, the autocorrelation of threat emotion decreased significantly from baseline to Stressor Anticipation (see autocorrelation slopes in Table 3). As hypothesized, these changes in threat emotion autocorrelations were qualified by significant interactions with the Level-2 predictors. Specifically, high CES-D and B-FNE and low RSE were related to significantly larger decreases in the autocorrelation of threat emotion from Baseline to Stressor Anticipation, indicating that the anticipation of a socially stressful event resulted in a significantly larger decrease in emotional inertia among participants with heightened sensitivity to social-evaluative threat. To illustrate these interactions between the measures of sensitivity to social-evaluative threat and changes in emotional inertia, we computed separate slopes at one standard deviation above and below the means of CES-D, RSE, and B-FNE scores (see right panel of Figure 2).

A final set of analyses examined whether the findings relating sensitivity to social-evaluative threat and emotional inertia reported above could be explained by individual differences in PA and NA. First, PA and NA were entered separately and together as Level-2 predictors of emotional inertia during Baseline and Stres-

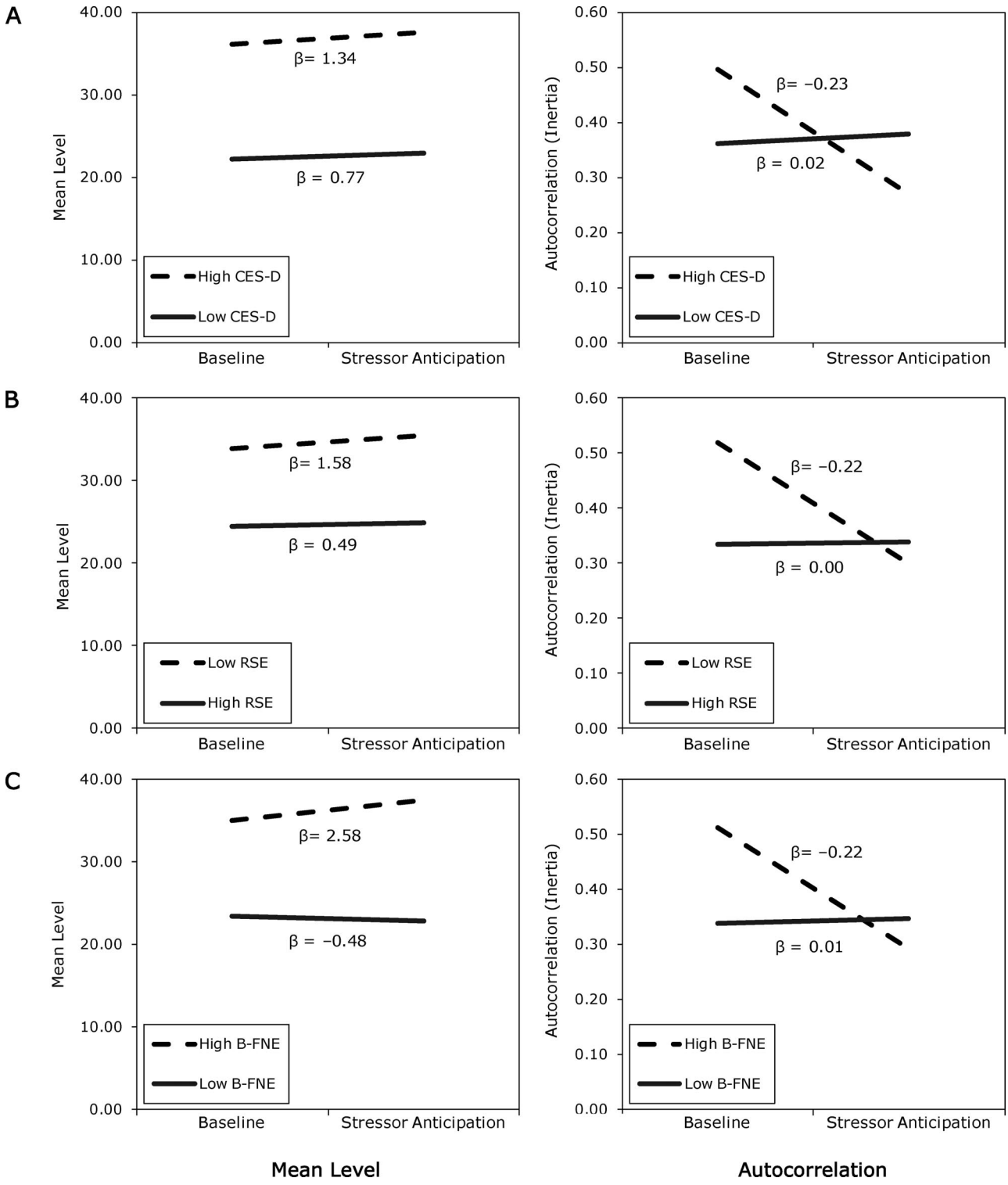

Figure 2. Interactions between sensitivity to social-evaluative threat and changes in mean level (left panels) and emotional inertia (right panels) of threat emotion from Baseline to Stressor Anticipation. Separate slopes are illustrated for participants scoring one standard deviation above (high) and one standard deviation below (low) the average depression (A), self-esteem (B), and fear of negative evaluation (C) scores. Beta weights in plots on the left (representing changes in mean level) are not comparable to beta weights in plots on the right (representing changes in autocorrelation) because of differences in the possible range of each parameter. CES-D = Center for Epidemiological Studies Depression scale; RSE = Rosenberg Self-Esteem scale; B-FNE = Brief Fear of Negative Evaluation scale.

Table 3
Multi-Level Models Estimating Change in Autocorrelations From Baseline to Stressor Anticipation, as a Function of Sensitivity to Social Evaluative Threat

			Level-1			Level-2						
							CES-D		RSE		B-FNE	
Outcome	Block	Effect	Parameter	β (*SE*)	*p*	Parameter	β (*SE*)	*p*	β (*SE*)	*p*	β (*SE*)	*p*
Threat emotion	Baseline	Mean level	β_{00}	29.20 (1.88)	<.001	β_{01}	7.01 (1.35)	<.001	−4.76 (1.70)	.007	5.78 (1.52)	<.001
		Autocorrelation	β_{10}	0.43 (0.04)	<.001	β_{12}	0.07 (0.03)	.009	−0.09 (0.03)	.002	0.09 (0.03)	.006
	Stressor anticipation	Mean level change	β_{20}	1.01 (0.87)	.251	β_{21}	0.29 (1.02)	.778	−0.55 (0.86)	.527	1.53 (0.86)	.079
		Autocorrelation change	β_{30}	−0.11 (0.05)	.019	β_{31}	−0.12 (0.04)	.001	0.11 (0.04)	.004	−0.11 (0.04)	.004

Note. Level-1 lagged predictors used to calculate emotion autocorrelations were group-mean centered. Intercept and slope values at Level-1 were estimated in a model with no predictors at Level-2 ($df = 70$). Level-2 predictors were standardized and entered in separate models ($df = 69$). CES-D = Center for Epidemiological Studies Depression scale; RSE = Rosenberg Self-Esteem scale; B-FNE = Brief Fear of Negative Evaluation scale.

sor Anticipation. Neither PA nor NA were significantly associated with emotional inertia during the Baseline or Stressor Anticipation blocks (all $ps > .38$), nor with changes in emotional inertia from Baseline to Stressor Anticipation (all $ps > .59$). To assess whether the effect of sensitivity to social-evaluative threat on changes in emotional inertia was independent of PA and NA, we reran all multilevel models reported above additionally controlling for PA and NA. Controlling for PA and NA did not affect the findings reported above: sensitivity to social-evaluative threat predicted significantly higher emotional inertia during Baseline (all $ps < .03$) and was associated with a greater decrease in emotional inertia from Baseline to Stressor Anticipation (all $ps < .02$) when controlling for PA and NA.

Discussion

Previous research has treated individual differences in emotion dynamics as stable, trait-like properties. However, the patterns of people's emotional fluctuations may themselves change under certain circumstances. The current study investigated the effect of anticipatory social stress on emotional inertia in daily life and how this effect is moderated by individual differences in sensitivity to social-evaluative threat. Consistent with previous studies (e.g., Kuppens, Allen, & Sheeber, 2010; Suls et al., 1998), depression, FNE, and low self-esteem were associated with higher emotional inertia in normal daily life. As predicted, the induction of anticipatory social stress significantly changed participants' emotional inertia, particularly among individuals with heightened sensitivity to social-evaluative threat.

Thus, despite beginning with higher levels of emotional inertia in normal daily life than their better-adjusted peers, more vulnerable participants displayed a larger drop in their inertia levels when anticipating a social stressor. Most strikingly, depression was associated with significantly lower inertia during the Stressor Anticipation period (see Table 2). Additional analyses demonstrated that neither PA nor NA predicted a similar pattern of changes in emotional inertia and showed that the effects of depression, self-esteem, and FNE were each independent of PA and NA. This indicates that a specific vulnerability to social stress, rather than a general disposition to feel positive or negative emotions, underlies the observed changes in emotional inertia. Furthermore, these results underscore the discriminant validity of our measures of sensitivity to social-evaluative threat.

We note that the current study's findings diverge from Kuppens, Allen, & Sheeber (2010) Study 2, in which depressed adolescents displayed higher emotional inertia during stressful interactions with their parents, compared with during positive interactions. However, whereas the current study examined emotional inertia of people's subjective feelings (measured by self-report), Kuppens and colleagues looked at the inertia of emotional (verbal and nonverbal) behavior coded by expert observers. These methodological differences may account for the divergent results. More importantly, whereas Kuppens and colleagues measured emotional inertia during the stressful interaction itself, in the current study we assessed inertia during the anticipatory period before a stressful encounter. Emotion dynamics may differ dramatically during the anticipation of a stressor compared with during the stressful event. Nevertheless, given the novelty of the current findings it will be important for future studies to replicate the pattern of larger

decreases in emotional inertia among more socially vulnerable participants during the anticipation of social stressors.

Possible Mechanisms Underlying Changes in Emotional Inertia

A number of possible mechanisms may account for the larger decrease in emotional inertia observed among more vulnerable participants during the anticipation of a social stressor. As mentioned earlier, lower inertia may be the result of ineffective emotion regulation. Given the limited coping resources available to psychologically vulnerable individuals (Taylor & Stanton, 2007), their attempts to regulate their threat emotions when anticipating a stressor may have been short-lived, resulting in more frequent emotional fluctuations (i.e., lower emotional inertia). Depression, in particular, is known to involve substantial emotion regulation impairments (Gross & Muñoz, 1995). For instance, individuals prone to depression are more likely to use ineffective strategies such as suppression when trying to down-regulate negative emotions (Ehring, Tuschen-Caffier, Schnülle, Fischer, & Gross, 2010). Although suppression may briefly succeed in reducing negative feelings (e.g., Liverant, Brown, Barlow, Roemer, 2008), it is often followed by ironic rebound effects (e.g., Wegner, Erber, & Zanakos, 1993). This pattern of successful suppression followed by ironic rebound would manifest itself as significantly lower levels of emotional inertia, similar to what we observed among more depressed participants during Stressor Anticipation in the current study. Another possibility is that anticipating a social stressor may have been more likely to induce vulnerable participants to alter their daily activities, which in turn may have influenced changes in their moment-to-moment feelings. Future studies are needed to elucidate the mechanisms mediating changes in emotional inertia under stress.

Is There an Optimal Level of Emotional Inertia?

As noted earlier, both extremely high and extremely low levels of emotional inertia are likely to be maladaptive, suggesting that there might be an optimal level (see also, Kashdan & Rottenberg, 2010). Given that participants with lower sensitivity to social-evaluative threat displayed smaller changes in their inertia levels (see Figure 2), it is tempting to interpret these findings as indicative of such an optimal level of inertia. If this were the case, it would raise another intriguing possibility: to the extent that the emotional inertia of more vulnerable participants dropped to levels similar to those observed in less sensitive participants, it could be argued that sensitivity to social-evaluative threat may be adaptive under certain conditions (i.e., in preparation for a socially stressful encounter) but may lead to maladaptive emotional functioning under normal circumstances (see Allen & Badcock, 2003 for a similar argument regarding the adaptiveness of depressive symptoms in certain contexts). However, these claims remain speculative and require further investigation. In any case, the findings of the current study caution against a straightforward interpretation of higher inertia as always indicative of emotional dysfunction and highlight the importance of studying emotional functioning in context.

Divergence Between Changes in Emotion Dynamics and Mean Levels

In addition to our main findings regarding emotional inertia, participants with higher depression and FNE and lower self-esteem scores also reported higher mean levels of threat emotions throughout the study, consistent with previous research (e.g., Bylsma, Taylor-Clift, & Rottenberg, 2011). However, these more vulnerable participants did not display a greater increase in threat emotions during the anticipation of a social stressor. These results are consistent with previous research showing that more vulnerable individuals are not necessarily more reactive to stressors in terms of (mean) emotional intensity (Waugh et al., 2008). Indeed, certain vulnerability factors, such as depression, may actually be associated with blunted emotional reactivity (Bylsma, Morris, & Rottenberg, 2008). Together, our findings suggest that increased vulnerability to social stress may be expressed in the dynamics (e.g., inertia) of threat emotions, but not necessarily in terms of the average intensity of these feelings in daily life.

Limitations of the Current Study

We note a number of limitations of the current study. First, although our approach of combining naturalistic and lab methods offers several advantages, it also raises the question of how diverging results obtained using each method should be reconciled. Specifically, although our experimental manipulation resulted in significant increases in threat emotions in the lab, we found no overall increase in mean levels of threat emotions in the ESM data. It is not uncommon to observe different patterns of emotional responding in the laboratory and in daily life (for a review, see Bylsma & Rottenberg, 2011). This may indicate that our manipulation of anticipatory social stress only had a short-lasting effect on the intensity of threat emotions. It is perhaps not surprising that after leaving the lab and returning to their usual daily activities, participants did not continue to experience higher levels of anxiety and stress over the entire anticipatory period (of approximately six hours) leading up to the social stressor. Crucially, despite not leading to a sustained increase in the intensity of threat emotions, anticipating a social stressor did markedly change emotional inertia levels, particularly among more vulnerable individuals. A second limitation concerns our exclusive reliance on self-reports to measure emotion dynamics. Future research would certainly benefit from attempting to relate the dynamics of subjective feelings in daily life to the temporal patterns of other emotion components (e.g., physiology, appraisals, action tendencies). However, at least for the moment, there is no real alternative to using self-report if one is interested in measuring how people subjectively feel (Barrett, Mesquita, Ochsner, & Gross, 2007). Finally, given that our participants were predominantly students, it is unclear to what extent the range of emotional inertia levels observed in the current sample represent the true extremes of the inertia continuum. Future studies with nonstudent and clinical samples would help to clarify under which circumstances certain levels of emotional inertia should be considered maladaptive.

Conclusion

The findings of the current study underline the importance of studying the patterns of changes and fluctuations in people's

emotional experiences in various contexts. We used a novel approach combining experience sampling and experimental methods that allowed us to study the effect of a standardized lab-induced stressor on emotion dynamics in daily life. We hope that this inspires future studies on the effects of experimental manipulations outside the laboratory (see also Bylsma & Rottenberg, 2011). Finally, by demonstrating that environmental and psychological vulnerability factors can interact to trigger changes in people's emotion dynamics, our findings suggest that emotion dynamics may not be stable trait-like properties of the person but rather are subject to both dispositional and situational influences.

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