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The Everyday Emotional Experience of Adults With Major Depressive Disorder: Examining Emotional Instability, Inertia, and Reactivity

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Investigators have begun to examine the temporal dynamics of affect in individuals diagnosed with major depressive disorder (MDD), focusing on instability, inertia, and reactivity of emotion. How these dynamics differ between individuals with MDD and healthy controls have not before been examined in a single study. In this study, 53 adults with MDD and 53 healthy adults carried hand-held electronic devices for approximately 7 days and were prompted randomly 8 times per day to report their levels of current negative affect (NA), positive affect (PA), and the occurrence of significant events. In terms of NA, compared with healthy controls, depressed participants reported greater instability and greater reactivity to positive events, but comparable levels of inertia and reactivity to negative events. Neither average levels of NA nor NA reactivity to, frequency or intensity of, events accounted for the group difference in instability of NA. In terms of PA, the MDD and control groups did not differ significantly in their instability, inertia, or reactivity to positive or negative events. These findings highlight the importance of emotional instability in MDD, particularly with respect to NA, and contribute to a more nuanced understanding of the everyday emotional experiences of depressed individuals.

Keywords: emotional variability, affective instability, experience sampling method, depression

Researchers have begun to examine the temporal dynamics of the emotional experiences of depressed individuals, assessing the instability, inertia, and reactivity of emotions. These related and sometimes overlapping emotional constructs, however, have typically been examined independently of each other. Findings concerning emotional instability in major depressive disorder (MDD) have not been well integrated into the literature examining emotional functioning in this disorder. Thus, our aims in this study are twofold. Our primary goal is to begin to develop an empirically supported model of emotional instability in MDD, focusing on difficulties in the regulation of emotions. Our second goal is to examine the nature of the relations among emotional instability, inertia, and reactivity.

Definitions and Overview of the Literature

Emotional Instability

Emotional or *affective instability* is generally conceptualized as frequent and intense fluctuations in emotions over time (e.g., Larsen & Diener, 1987; Trull et al., 2008). Earlier work used the term *variability* to refer to instability; however, variability, which captures the general dispersion of scores, is only one facet of instability. Some researchers have criticized the use of variance or standard deviation as a measure of instability, arguing that these indices do not include temporal dependency, another important facet of instability. One approach to calculating instability that has been recommended by investigators is the use of mean square successive difference (MSSD; e.g., Ebner-Priemer, Eid, Kleindienst, Stabenow, & Trull, 2009). MSSD takes into account both

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variability and temporal dependency, with higher MSSD reflecting greater instability (e.g., Jahng, Wood, & Trull, 2008). Jahng et al. (2008) have shown that MSSD can be factorized as a product of variance and temporal dependency (Equation 4, p. 356).

Findings of studies that examine emotional instability and variability in depression have been inconsistent. Whereas some investigators have found a weak or an inverse relation between MDD and emotional variability (e.g., Cowdry, Gardner, O'Leary, Leibenluft, & Rubinow, 1991; Golier, Yehuda, Schmeidler, & Siever, 2001), other researchers have found a positive relation. For example, rates of "ups and downs of mood" in a community sample significantly predicted diagnoses of depressive disorders, even after controlling for the effects of gender (Angst, Gamma, & Endrass, 2003). Similarly, both currently and formerly depressed individuals reported greater emotional instability than did individuals with no history of MDD (Thompson, Berenbaum, & Bredemeier, 2011). Finally, compared to nondepressed individuals, individuals with MDD reported greater moment-to-moment instability in negative affect (NA) but not in positive affect (PA; Peeters, Berkhof, Delespaul, Rottenberg, & Nicolson, 2006).

Emotional Inertia

Emotional inertia is defined as the extent to which emotions are resistant to change, or the extent to which emotions are persistent over time (Suls, Green, & Hills, 1998). This construct is typically calculated by using the autocorrelation of a variable over time (e.g., feelings of anger; Box, Jenkins, & Reinsel, 2008), with higher autocorrelations reflecting greater resistance to change. Like emotional instability, inertia involves temporal dependency; unlike emotional instability, however, inertia does not yield information about the variability or the amplitude of fluctuations in emotions (Ebner-Priemer et al., 2007; Jahng et al., 2008).

Assessments of happiness, anger, and dysphoria were found to be stronger predictors of subsequent levels of these emotions in depressed than in nondepressed adolescents (Kuppens, Allen, & Sheeber, 2010; Study 2). Compared with their nondepressed peers, depressed adolescents exhibited nonverbal behaviors and comments reflecting negative and positive emotions during a family interaction task that were more resistant to change. Finally, higher levels of inertia in a similar laboratory task were found to predict subsequent onset of MDD among never depressed adolescents (Kuppens et al., 2011).

Emotional Reactivity

Emotional reactivity refers to emotional reactions that are elicited in response to a circumscribed external "event," such as a valenced stimulus or a specific daily event. Unlike emotional instability and inertia, emotional reactivity does not provide a broad overarching description of individuals' emotional experiences. Instead, emotional reactivity is constrained to the subset of emotional experiences that are elicited in response to an event. Rottenberg, Gross, and Gotlib (2005) formulated a theory of emotion context insensitivity (ECI) that posits that, compared with nondepressed individuals, depressed persons experience decreased positive and negative responses to positive and negative stimuli. ECI has garnered strong support in laboratory settings, as evidenced by self-report, behavioral, and psychophysiological responses (see Bylsma, Morris, & Rottenberg, 2008, for a review), but its support in naturalistic settings has been equivocal. To date, only two nontreatment studies have used experience sampling methods (ESM) to compare the emotional reactivity to daily life events of depressed and healthy controls (Bylsma, Taylor-Clift, & Rottenberg, 2011; Peeters, Nicolson, Berkhof, Delespaul, & deVries, 2003). The common finding of these studies was that depressed individuals showed greater reductions in NA in response to daily positive events than did healthy controls. Peeters et al. (2003) also found that depressed individuals had greater PA responses to positive events. Although these findings are contrary to the predictions of ECI, they suggest that depressed individuals experience some form of enhanced-mood response to positive daily events (i.e., "mood-brightening" effect; Bylsma et al., 2011).

Emotional Instability and MDD: The Roles of Interpersonal, Cognitive, and Emotional Regulation

Despite the equivocal evidence concerning affective instability in MDD, we posit that depressed individuals will be characterized by high instability of NA above and beyond what is explained by their high baseline levels of NA. We posit three reasons to expect a positive relation between MDD and instability of NA, the first two of which were presented in Thompson, Berenbaum, & Bredemeier (2011). First, depressed individuals play a role in generating stressful life events, many of which are interpersonal in nature (Connolly, Eberhart, Hammen, & Brennan, 2010), and high levels of emotional instability may contribute to the experience and occurrence of stressful life events (e.g., getting fired from a job). In fact, after controlling for shared variance with neuroticism, emotional instability was found to predict impairments in romantic relationships at a 12-month follow-up (Miller & Pilkonis, 2006). Instability has also been linked to angry hostility and impulsiveness (Miller, Vachon, & Lynam, 2009), neither of which is generally adaptive within interpersonal contexts.

The second reason we hypothesize a positive relation between MDD and instability of NA involves the negative biases in cognitive functioning that characterize depressed individuals. For example, depressed individuals demonstrate selective attention to and memory for negative stimuli and difficulties in controlling the contents of working memory (see Gotlib & Joormann, 2010). Although these patterns of cognitive functioning likely contribute to higher levels of NA, the products of these cognitive processes may also act as internal events to which depressed individuals respond. The ebbing and flowing of these cognitive processes over time with the occurrence of activating events would lead to variable or labile NA.

The third reason we hypothesize a positive relation between instability of NA and MDD involves the construct of emotion dysregulation. As is the case with many mental health disorders, MDD is characterized by difficulties regulating emotion (e.g., Berenbaum, Raghavan, Le, Vernon, & Gomez, 2003; Kring & Bachorowski, 1999). Individuals with depression report high levels of rumination (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008, for a review) and emotional suppression (e.g., Ehring, Tuschen-Caffier, Schnulle, Fischer, & Gross, 2010). For example, even though healthy controls and individuals with anxiety and depressive disorders reported similar increases in negative emotions in response to a film, the anxious and depressed individuals suppressed their emotions to a greater extent (Campbell-Sills, Barlow, Brown, & Hofmann, 2006). It is important that this suppression was associated with a subsequent increase in negative emotions. Thus, we posit that ineffective emotion regulation will lead to more labile affect.

Whether depressed individuals and healthy controls will differ in their instability of PA is less clear. As we noted above, depressed individuals have been found to have blunted emotional responses to valenced stimuli in the laboratory (Bylsma et al., 2008) and decreased responsivity to reward (e.g., Pizzagalli, Iosifescu, Hallett, Ratner, & Fava, 2009), suggesting that they will also have lower levels of instability of PA. On the other hand, to the extent that affective instability is driven by individuals' reactions to external events (i.e., emotional reactivity), findings of mood brightening (Bylsma et al., 2011; Peeters et al., 2003) lead to the prediction that depressed individuals will exhibit greater instability of PA than will healthy controls. This may be offset, however, by depressed individuals experiencing fewer positive events than do healthy controls (e.g., Bylsma et al., 2011; Peeters et al., 2003). Finally, in the only ESM study to date to examine this construct between depressed and nondepressed participants, Peeters et al. (2006) found no differences in instability of PA.

Understanding the Overlap of Emotional Instability, Inertia, and Reactivity

Because the literatures examining emotional instability, inertia, and reactivity in depression are largely independent, the nature of the relation among these facets of emotional dynamics has not been fully examined. There is conceptual overlap between the constructs of emotional instability and emotional inertia, and between emotional instability and emotional reactivity. Whereas both emotional instability and inertia involve the concept of temporal dependency, only instability involves variance (Jahng et al., 2008; Kuppens et al., 2010). In this study, we used ESM to examine emotional instability, inertia, and reactivity to positive and negative events in adults with MDD and in healthy controls.

For two reasons we hypothesize that emotional instability and inertia will be inversely related at high levels of either construct. First, equations for both inertia and instability include temporal dependency, and increasing temporal dependency increases inertia and decreases instability (when variance remains constant). Second, it is unlikely that high levels of instability would be associated with high levels of emotional inertia (i.e., highly resistant to change). Given this hypothesis, combined with our expectation that individuals with MDD will have higher levels of instability of NA than will healthy controls, we hypothesize that depressed individuals will have lower levels of inertia of NA than will healthy controls. We also predict a positive relation between emotional instability and emotional reactivity because emotional responses that constitute emotional reactivity should be subsumed in overall emotional instability. On the other hand, we posit that emotional reactivity will only partially explain levels of emotional instability. Finally, we do not expect that group differences in emotional instability will be fully explained by the frequency or intensity of experienced significant events.

Method

Participants and Procedure

One hundred and six participants between the ages of 18 and 40 were recruited for participation in a large project (see Mata et al., 2011; Thompson, Mata, et al., 2011). All participants were native English speakers. Individuals were eligible to participate if they either (a) experienced no current–past history of any mental health disorders (control group; $n = 53$); or (b) were currently diagnosed with MDD (depressed group; $n = 53$) as assessed by the Structured Clinical Interview for *DSM–IV* Axis I Disorders (SCID-I; First, Spitzer, Gibbon, & Williams, 2001).[1] Additional eligibility requirements for the control group included a Beck Depression Inventory–II (BDI-II; Beck, Steer, & Brown, 1996) score of 9 or less. Eligibility for the depressed group included a BDI-II score of 14 or more, and an absence of alcohol–drug dependence in past 6 months, Bipolar I or II diagnoses, and psychotic disorders. The final sample of 106 participants excluded 22 participants because of BDI-II scores being outside of the range of eligibility ($n = 7$), equipment failure ($n = 12$), or noncompliance (e.g., responding to less than 41 prompts; $n = 3$).

Individuals were recruited from the communities of Ann Arbor, Michigan, and Stanford, California, through advertisements posted online and at local agencies and businesses. Each site recruited approximately 50% of each group. We combined samples to increase the reliability and generalizability of the results (see Mata et al., 2011, for descriptive information by site).

At their first session, participants completed the lifetime SCID, which was administered by extensively trained graduate and postbaccalaureate students. Diagnostic reliability was assessed by randomly selecting and rerating recorded interviews. Our team has achieved excellent interrater reliability for a major depressive episode ($k = .93$) and for classifying participants as nonpsychiatric controls ($k = .92$; Levens & Gotlib, 2010). Participants returned to the laboratory for a second session to complete a series of self-report questionnaires and computer tasks. They were also individually instructed on the experience sampling protocol, including completing a full practice trial.

Participants carried a hand-held electronic device (Palm Pilot Z22) that was programmed using the Experience Sampling Program 4.0 (Barrett & Feldman Barrett, 2000). Participants were prompted (via a tone signal) eight times per day between 10 a.m. and 10 p.m. The majority of participants carried the device for 7 to 8 days to be prompted 56 times. Prompts occurred at random times within eight 90-min windows per day; thus, prompts could occur between 2 and almost 180 min apart ($M = 93$ min, $SD = 38$ min). After participants were prompted, they had 3 min to respond to the initial question. Depressed and nondepressed participants did not

[1] Thirty-six percent of participants with major depressive disorder (MDD; $n = 18$ of 50) met criteria for a current *DSM–IV–TR* anxiety disorder, excluding specific phobias. Fifty percent ($n = 25$) of those with MDD met criteria for a current or past *DSM–IV–TR* anxiety disorder. There were no significant differences between MDDs with and without current comorbidities in levels of PA and NA inertia, NA or PA reactivity to positive or negative events, or in NA or PA variability, although the sample sizes may not have been sufficient to yield reliable group differences.

differ in number of total prompts, completed prompts, or prompts completed in succession (see Table 1).[2] Participants provided informed consent and were compensated for their participation, with an extra incentive for responding to more than 90% of the prompts. The protocol was approved by both universities' Institutional Review Boards.

Measures

Affect ratings. At each trial, participants reported their current levels of negative and positive affect. Using a 4-point scale, ranging from 1 (*not at all*) to 4 (*a great deal*), participants indicated the extent to which they were currently feeling each of seven negative emotions (sad, anxious, angry, frustrated, ashamed, disgusted, guilty) and each of four positive emotions (happy, excited, alert, active). The affect words were drawn from various sources, including the Positive Affect Negative Affect Scale (Watson, Clark, & Tellegen, 1988) and Ekman's basic emotions (e.g., Ekman, Friesen, & Ellsworth, 1972). We calculated the between- and within-person reliability using MIXED methods (Shrout & Lane, 2011). For NA, the between-person reliability was .998 and the within-person reliability was .84. For PA, the between-person reliability was .995 and the within-person reliability was .75. These within-person reliability values are in the range of moderate to substantial (Shrout, 1998).

Significant events. At each prompt, participants were asked whether they had experienced a significant event since the previous prompt. If they endorsed "yes," they were asked to rate the intensity of the event by moving a slider along a continuum anchored with the words, *positive* and *negative*. Their answer was coded as a number from 1 to 100. Events rated between 1 and 50 were coded as positive, and events rated between 51 and 100 were coded as negative. Frequency of events was computed by dividing the number of prompts at which participants indicated an event had occurred by the total number of prompts to which participants responded. Intensity of events was computed by averaging across the severity score for each type of event. For ease of interpretation, all intensity scales were recoded on a 1 to 50 scale, with a score of 50 indicating the most pleasant for a positive event and the most unpleasant for a negative event. No other information was collected in regard to the events.

Statistical Analyses

Because of the nested data structure (prompts nested within individuals), we tested our hypotheses using multilevel modeling whenever possible. Multilevel modeling simultaneously estimates within- and between-person effects (Krull & MacKinnon, 2001) while handling varying time intervals between prompts and missing data (Snijders & Bosker, 1999). It is important that multilevel modeling does not assume independence of data points. We used hierarchical linear modeling (HLM 6.08; Raudenbush, Bryk, & Congdon, 2008) and report parameter estimates with robust standard errors. Full models, all of which were random effects models (i.e., intercepts and slopes were allowed to vary), are presented below. In the equations below, $_i$ represents prompts and $_j$ represents participants. Whenever depressive status is included as a Level 2 (between persons) variable, it was dummy-coded (control group = 0; MDD group = 1).

Results

Participant Characteristics

The MDD and control groups did not differ significantly in gender, race–ethnic composition, or educational attainment (see Table 1). Individuals with MDD, however, were significantly older than control participants.[3]

Within- and between-person variance. To examine the proportion of variance of NA and PA accounted for by within- and between-person levels, we conducted two intercept-only models (Raudenbush & Bryk, 2002), with either NA or PA serving as the dependent variable and no Level 1 or Level 2 predictors. For NA, the intercept-only model revealed significant Level 2 variance, $\text{var}(u_{0j}) = .285$, $\chi^2(105) = 7{,}300.52$, $p < .001$, indicating significant variability in participants' experience of NA and providing evidence against possible floor and ceiling effects. The resulting intraclass correlation coefficient was .61, indicating that 39% of the variance in NA was at the within-person level and 61% at the between-persons level. For PA, the intercept-only model also yielded significant Level 2 variance, $\text{var}(u_{0j}) = .235$, $\chi^2(105) = 3{,}769.54$, $p < .001$. A total of 54% of the variance in PA was at the within-person level and 46% at the between-persons level.

Next, we examined the proportion of variance explained by depression status (Level 2 variable). We conducted two means-as-outcomes models (Raudenbush & Bryk, 2002), predicting either NA or PA (centered for each individual):

Level 1 Model (level of prompts):

$$\text{Affect}_{ij} \text{ (either NA or PA)} = \beta_{0j} + r_{ij}. \tag{1a}$$

Level 2 Model (level of participants):

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{depression status}) + u_{0j}. \tag{1b}$$

Affect_{ij} represents NA or PA for participant $_j$ at prompt $_i$, and r_{ij} represents the Level 1 (within person) random effect. β_{0j} represents the within-person mean affect (i.e., NA or PA). γ_{00} represents the mean affect for the control group; γ_{01} is the difference in

[2] We conducted a series of analyses to examine missing data. First, on the basis of recommendations by Stone and Shiffman (2002), we assessed whether missing data were related to the time of the prompts (minutes since the first prompt of the day). Using multilevel modeling, we examined whether linear or quadratic time-of-day effects were associated with the occurrence of missing data by coding each prompt for each participant (0 = not missing, 1 = missing). Neither linear nor quadratic time of day was associated with the missing data variable, $t\text{s} < .91$. Second, percentage of compliance (completed prompts divided by total prompts) was not significantly related to age or education level, $r\text{s} < .10$, sex, $F(1, 104) = 0.24$, $p = .63$, or race, $F(5, 100) = 0.73$, $p = .60$. Finally, we repeated all presented multilevel modeling analyses, including percentage of compliance as a Level 2 variable. There were no changes to the significance level of any coefficients, suggesting that the pattern of missing data is not an issue.

[3] Age was not significant when it was included as a covariate in any of the models examining emotional instability, reactivity, or inertia of PA or NA. Further, the significance levels were not different from those in the analyses in which we did not include age as a covariate. Thus, when age-related variance was controlled, all nonsignificant findings remained nonsignificant, and all significant findings remained significant.

Table 1
Demographic and ESM Information by Participant Group

Variable	Group				Difference test
	Healthy Control		MDD		
Gender (% women)	67.9%		71.7%		$\chi^2(1) = 0.18, p = .83$
Race–Ethnicity					$\chi^2(5) = 7.79, p = .17$
African American	9.4%		5.7%		
Asian American	17.0%		3.8%		
Caucasian	62.3%		73.6%		
Latino/a	1.9%		3.8%		
Multiracial	9.4%		9.4%		
Other	0		3.8%		
Age (*M*, *SD*)	25.4	(6.4)	28.2	(6.4)	$t(104) = 2.19, p < .05$
Education					$\chi^2(3) = 6.67, p = .08$
High school	0%		11.3%		
Some college	47.2%		37.7%		
Bachelor's degree	43.4%		43.4%		
Professional degree	9.4%		7.5%		
Event frequency[a]					
Positive event (%, *M*, *SD*)	11	(10)	9	(9)	$t(104) = 0.89, p = .38$
Negative event (%, *M*, *SD*)	3	(4)	7	(8)	$t(104) = 3.07, p < .01$
Event intensity[b]					
Positive event (*M*, *SD*)	32.4	(11.1)	22.7	(9.6)	$t(84) = 4.33, p < .001$
Negative event (*M*, *SD*)	24.8	(6.4)	32.1	(8.9)	$t(67) = 3.73, p < .001$
Total prompts (*M*, *SD*)	54.5	(2.7)	54.4	(3.4)	$t(104) = 0.13, p = .90$
Completed prompts (*M*, *SD*)	42.2	(7.8)	44.0	(7.6)	$t(104) = 1.08, p = .29$
Percentage of completed prompts (*M*, *SD*)	77.9	(13.3)	81.0	(13.1)	$t(104) = 1.24, p = .22$
Successive prompts completed w/in day (*M*, *SD*)	27.7	(9.8)	29.5	(9.7)	$t(104) = 0.95, p = .35$
Minutes between prompts (*M*, *SD*)	92.8	(3.9)	93.2	(4.2)	$t(104) = 0.55, p = .59$

Note. MDD = major depressive disorder; ESM = experience sampling method.
[a] The proportion of prompts in which participants indicated that a significant event had occurred. [b] Intensity of event: 1 = least positive (negative), 50 = most positive (negative).

the mean affect between the two groups, and u_{0j} represents the Level 2 (between persons) random effect.

For NA, depression status significantly improved the model fit for NA, $\chi^2(1) = 71.06, p < .001$. Level 2 variance was significant, $\text{var}(u_{0j}) = .145$, $\chi^2(104) = 3{,}729.30$, $p < .001$. The resulting intraclass correlation coefficient indicated that depression status explained 49% of the between-group variance, or approximately 28.1% of the overall variance in NA. Depression status also significantly improved the model fit for PA, $\chi^2(1) = 27.26, p < .001$, with Level 2 variance being significant, $\text{var}(u_{0j}) = .181$, $\chi^2(104) = 2{,}976.49, p < .001$. Depression status explained 23% of the between-group variance, or approximately 10.3% of the overall variance in PA.

Examining Temporal Dynamics of Emotional Experiences

Emotional instability. Using two different methods, we examined the relation between emotional instability and depression. First, we computed residuals (as indicators of instability) of NA and PA at each prompt for each participant (Level 1). Then, we examined whether there were group differences in the absolute values of these residuals. The models were similar to those shown in Equations 1a and 1b with one exception: The outcome variables were the absolute values of the residual_{ij} of NA or PA. Consistent with our hypotheses, the NA residual scores for the MDD group, $\gamma_{01} = .274$, $SE = 0.02$, were significantly higher than those for the healthy control group, $\gamma_{00} = .13$, $SE = 0.01$; $t(104) = 11.01, p < .001$. In contrast, the MDD and healthy control groups did not differ significantly in their PA residual scores, $t(104) = 0.81, p = .42$.

Because the first analysis we conducted to examine emotional instability did not assess temporal dependency, we examined emotional instability by using MSSD scores (a nonmultilevel modeling analysis). MSSD scores are calculated by taking the mean of the squared difference between successive observations across a sampling period (see Table 1 for descriptive information). Three outliers were removed because their values were more than 3 *SD*s above the mean. In addition, NA MSSD scores were transformed using the base-10 logarithm of the scores to achieve acceptable for skewness and kurtosis.

We examined whether groups differed in instability of NA and PA by conducting a repeated measures analysis of variance (ANOVA) with group as the between-subjects variable and valence (positive, negative) as the within-subject factor. Consistent with our hypotheses, this analysis yielded a significant interaction of group and valence, $F(1, 99) = 95.94, p < .001$. Follow-up *t* tests revealed that compared to healthy controls, individuals with MDD reported significantly greater instability of NA but similar levels of instability of PA (see Table 2). Because varying time intervals between prompts can affect MSSD scores (e.g., Ebner-Priemer & Sawitzki, 2007; Trull et al., 2008), we divided each successive difference score by its time interval. After adjusting for minutes between intervals, the results were unchanged: Compared

Table 2
Facets of Everyday Emotional Experiences by Participant Group

Variable	Group: Healthy control	Group: MDD	Difference test
Mean affect	*M* (*SE*)	*M* (*SE*)	
NA	1.14 (0.02)	1.89 (0.07)	$t(104) = 10.06, p < .001$
PA	2.15 (0.06)	1.69 (0.08)	$t(104) = 5.58, p < .001$
Emotional instability (MSSD)[a]	*M* (*SD*)	*M* (*SD*)	
NA	0.07 (0.10)	0.40 (0.25)	$t(101) = 10.07, p < .001$
PA	0.40 (0.24)	0.38 (0.27)	$t(102) = 0.43, p = .67$
Emotional inertia (autocorrelation)	*M* (*SD*)	*M* (*SD*)	
NA	0.18 (0.27)	0.21 (0.27)	$t(102) = 0.53, p = .60$
PA	0.24 (0.24)	0.22 (0.24)	$t(104) = 0.45, p = .65$

Note. MDD = major depressive disorder; NA = negative affect; PA = positive affect; MSSD = mean square successive difference.
[a] Raw scores without outliers 3 *SD*s above–below mean are presented for means and *SD*s; *t* tests were conducted on NA values transformed using the base-10 logarithm of the scores to correct for skewness and kurtosis.

with healthy controls, individuals with MDD reported greater instability of NA, $t(102) = 10.18$, $p < .001$, but similar levels of instability of PA, $t(104) = 0.87$, $p = .39$.

To rule out the possibility that the group difference in instability of NA was driven by higher mean levels of NA, and as recommended by Russell, Moskowitz, Zuroff, Sookman, and Paris (2007) and Ebner-Priemer et al. (2009), we conducted an ANOVA on instability of NA, including mean level of NA as a covariate. Both the covariate, $F(1, 100) = 4.37$, $p < .05$, and the main effect of group, $F(1, 100) = 34.86$, $p < .001$, were significant, suggesting that group differences in affective instability of NA remained even after taking into account mean levels of NA.

Emotional inertia. Next, we examined group differences in emotional inertia of NA and PA or the extent to which affect at one prompt *t* predicts affect at the subsequent prompt $t + 1$ within days. Following Kuppens et al.'s (2010) approach, we conducted two multilevel models: (a) NA_{t+1} regressed onto $NA_{t,}$ and (b) PA_{t+1} regressed onto PA_t. All NA and PA variables (those at *t* and $t + 1$) served as the Level 1 variables; predictors were centered for each individual.

Level 1 Model:

$$\text{Affect}_{(t+1)ij} = \beta_{0j} + \beta_{1j}(\text{affect}_t) + r_{ij}. \quad (2a)$$

Level 2 Model:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{depression status}) + u_{0j}, \text{ and} \quad (2b)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{depression status}) + u_{1j}. \quad (2c)$$

See Equation 1 for a description of coefficients. Additional coefficients include the following: β_{1j} represents the degree to which affect_t is related to affect_{t+1} (i.e., the autocorrelation or inertia; Kuppens et al., 2010), γ_{10} represents the slope between NA_t and $NA_{t+1}$for the control group, and γ_{11} represents the difference in the slopes between NA_t and NA_{t+1} between the two groups.

For the NA inertia model, the mean level of NA_{t+1} for the control group was greater than zero, and the MDD group reported significantly greater NA_{t+1} than did the control group (see Table 3). The inertia of NA (i.e., the slope between NA_t and NA_{t+1}) for both groups was significantly different from zero. The MDD and control participants did not differ, however, in their inertia of NA. Because this finding supports the null hypothesis, we computed the confidence interval (CI) [−.11, .13]. For the PA inertia model, the control group reported PA_{t+1}, which was significantly greater than zero, and MDD participants reported significantly lower levels of PA_{t+1} than did control participants. Inertia of PA was significantly different from zero for both groups, but the groups did not differ significantly in inertia of PA, CI [−.14, .06].

Emotional reactivity. At each prompt, participants indicated whether any significant events had occurred since the previous prompt (69 participants reported experiencing negative events, and 86 participants reported experiencing positive events). As shown in Table 1, the MDD group reported experiencing more frequent negative events than did the control group, but the groups did not differ in the frequency of positive events. Further, the MDD group rated their negative events as significantly more negative and their positive events as significantly less positive than did the control group.

Next, we examined changes in participants' affect at prompts during which they reported having experienced a significant event since the previous prompt. We conducted a series of multilevel analyses examining affect after negative and positive events, controlling for affect at the previous prompt. Models were run separately for negative and positive events, and the dependent variable was either NA or PA at time *t*. The Level 1 predictors were the occurrence of an event (dummy coded) and NA or PA at the preceding prompt, *t*-1, which were person centered. Below are the equations for examining emotional reactivity during the occurrence of negative events.

Level 1 Model:

$$\text{Affect}_{ij(t)} = \beta_{0j} + \beta_{1j}(\text{whether negative event occurred}) + \beta_{2j}(\text{affect}_{t\text{-}1}) + r_{ij}. \quad (3a)$$

Level 2 Model:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{depression status}) + u_{0j}, \quad (3b)$$

Table 3
Emotional Inertia as a Function of Depression Status

Fixed effect	Unstandardized coefficient	*SE*	*t*(104)	*p*
	Outcome variable: NA_{t+1}			
For intercept 1, β_0				
Intercept, γ_{00}	1.14	0.02	49.02	<.001
MDD, γ_{01}	0.74	0.08	9.94	<.001
For NA_t slope, β_1				
Intercept, γ_{10}	0.24	0.05	4.73	<.001
MDD, γ_{11}	0.01	0.06	0.16	.87
	Outcome variable: PA_{t+1}			
For intercept 1, β_0				
Intercept, γ_{00}	2.16	0.07	32.71	<.001
MDD, γ_{01}	−0.46	0.09	−5.33	<.001
For PA_t slope, β_1				
Intercept, γ_{10}	0.30	0.04	8.35	<.001
MDD, γ_{11}	−0.04	0.05	−0.81	.42

Note. MDD represents the contrast between the healthy control group and MDD group.

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{depression status}) + u_{1j}, \text{ and} \quad (3c)$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(\text{depression status}) + u_{2j}. \quad (3d)$$

Results for NA and PA are presented in Tables 4 and 5, respectively. Both groups reported significant increases in NA at the prompts in which a *negative event* was reported to have occurred since the previous prompt. These increases in NA did not differ significantly by group, indicating that the two groups had a comparable increase in NA following negative events. Neither group had a significant decrease in PA following a negative event; moreover, the groups did not differ in change in PA after controlling for levels of PA at the previous prompt. Only the MDD group reported a significant decrease in NA (and significantly greater than the control group) at prompts at which they reported that a *positive event* occurred. The groups reported equivalent and significant increases in levels of PA at prompts in which they reported having experienced a positive event.

Although depressed individuals respond to negative events with changes in NA and PA similar to those found in control participants, the higher frequency with which depressed individuals experience negative events, as well as the greater intensity of these events, may be driving the higher levels of instability of NA found in the MDD group. Given the significant group difference in reduction of NA to positive events, this type of event may also influence the relation between MDD and affective instability of NA. To test these possibilities, we conducted an analysis of covariance (ANCOVA) predicting instability of NA, with depression status (MDD, control) as a fixed effect and frequency and intensity of negative and positive events and NA reactivity to negative and positive events as six simultaneous covariates. First, we calculated three NA scores per participant: the average NA across prompts during which participants reported (a) no significant events; (b) positive events; and (c) negative events. Two outliers with prompts at which no significant events occurred were omitted from analyses. Residualized scores of NA at prompts with positive events and NA at prompts with negative events, both adjusted for NA at prompts with no significant events, were computed to capture NA reactivity to positive and negative events, respectively. The results of the ANCOVA indicated that depression status continued to be a significant predictor of instability of NA, $F(1, 52) = 40.79$, $p < .001$, even after controlling for these six variables. Thus, the greater instability of NA in MDD than in control participants is not accounted for by NA reactivity to, or intensity or frequency of, positive or negative events.

Examining Relations Between Emotional Dynamics

For each of the following comparisons, we examined within-person relations between constructs across the sampling period (within days). For instability, we used MSSD of NA and PA as described above. For inertia, we calculated an autocorrelation coefficient (see Jahng, Wood, & Trull, 2008, Equation 2). Because

Table 4
Emotional Reactivity of Negative Affect to Events as a Function of Depression Status, β (SE)

Variable	Negative event: MDD	Negative event: Healthy Control	Negative event: Difference	Positive event: MDD	Positive event: Healthy Control	Positive event: Difference
Intercept	1.84 (0.07)**	1.12 (0.02)	0.73 (0.07)**	1.90 (0.07)**	1.14 (0.05)**	0.76 (0.08)**
Event	0.50 (0.08)**	0.45 (0.09)**	0.05 (0.12)	−0.17 (0.05)**	−0.03 (0.04)	−0.14 (0.06)*
NA previous prompt	0.24 (0.04)**	0.23 (0.05)**	0.01 (0.06)	0.25 (0.04)**	0.24 (0.06)**	0.01 (0.07)

Note. MDD = major depressive disorder; NA = negative affect.
* $p < .05$. ** $p < .01$.

Table 5
Emotional Reactivity of Positive Affect to Events as a Function of Depression Status, β (SE)

Variable	Negative event: MDD	Negative event: Healthy Control	Negative event: Difference	Positive event: MDD	Positive event: Healthy Control	Positive event: Difference
Intercept	1.70 (0.06)**	2.16 (0.07)**	−0.46 (0.09)**	1.66 (0.05)**	2.12 (0.07)**	−0.47 (0.08)**
Event	−0.05 (0.05)	−0.14 (0.08)	0.09 (0.09)	0.38 (0.05)**	0.36 (0.06)**	0.01 (0.08)
PA previous prompt	0.25 (0.03)**	0.29 (0.04)**	−0.04 (0.05)	0.24 (0.03)**	0.28 (0.04)**	−0.04 (0.05)

Note. MDD = major depressive disorder; PA = positive affect.
** $p < .01$.

of missing data, which are characteristic of ESM, using successive scores for autocorrelation can be problematic; consequently, we adjusted the numerator and denominator of the autocorrelation to reflect means (instead of sums). Nevertheless, as shown in Table 1, the groups did not differ in the total number of completed prompts or the number of successive responses. As presented in Table 2, depression status did not predict inertia of NA or PA, replicating the multilevel model findings presented above. For emotional reactivity, we used the residualized scores of NA and PA to positive and negative events, both adjusted for NA and PA at which no significant events were reported, respectively (as described for NA reactivity above). We examined linear and quadratic relations between the variables. When scatter plots suggested a nonlinear relation, we examined both linear and quadratic relations.

Emotional instability and inertia. We first examined whether emotional instability and inertia are inversely related. The linear effect of instability on inertia was not significant, $\beta = .21$, $p = .16$, but the quadratic effect of instability of NA was inversely associated with inertia of NA, $\beta = -.26$, $p = .08$. At low levels of instability (i.e., near zero), there was a weak positive relation with inertia. Thus, our hypothesis was supported at higher, but not at lower, levels of these variables. Next, we examined the within-person relation between instability of PA and inertia of PA. There was a significant negative relation between instability of PA and inertia of PA, $r_s = -.22$, $p < .05$. Finding that higher levels of instability are associated with lower levels of inertia is consistent with our hypothesis.

Emotional instability and reactivity. Next, we examined whether emotional instability and reactivity are positively related. Indeed, instability of NA was significantly correlated with NA reactivity to negative events, $r_s = .36$, $p < .01$. Instability of NA and NA reactivity to positive events showed a marginally significant linear effect, $\beta = -.30$, $p = .07$, and a significant quadratic effect of NA instability, $\beta = .43$, $p < .05$, suggesting an inverse relation at low levels of NA instability and reactivity, and a positive relation at high levels of NA instability and reactivity. Instability of PA was significantly correlated with PA reactivity to positive events, $r_s = .21$, $p = .05$, but not with PA reactivity to negative events, $r_s = .06$, $p = .63$.

Emotional reactivity and emotional inertia. Finally, we examined the relation between emotional reactivity and inertia. There were no significant associations between inertia of NA and NA reactivity to positive or negative events, $rs_s < .10$, $ps > .45$, or between inertia of PA and PA reactivity to negative events, $r_s = -.15$, $p = .23$. There was a marginal linear effect, $\beta = .20$, $p = .06$, and a significant quadratic effect of PA inertia with PA reactivity to positive events, $\beta = -.29$, $p < .01$. Thus, the relation between PA inertia and PA reactivity to positive events follows an inverse U shape: there was positive relation between these inertia and reactivity of PA at low levels of both variables, and a negative relation at high levels of inertia and reactivity of PA.

Discussion

Researchers are only beginning to examine temporal aspects of the emotional experiences of individuals with MDD. Consistent with the central aim of assessing emotional instability in depression, we found a clear pattern of findings: depressed individuals reported greater instability of NA, but not of PA, than did healthy controls. Although previous research that examined the relation between emotional instability and MDD has yielded equivocal results, greater instability of NA in depressed individuals replicates what Peeters et al. (2006, p. 387) referred to as an "unanticipated" finding. Combined with Peeters et al.'s results, our findings highlight the importance of assessing emotional instability separately for NA and PA.

We examined several factors that may contribute to the high levels of instability of NA in depressed individuals. It is important to note that depression status continued to be associated with instability of NA even after taking into account average levels of NA. Consistent with previous research, we found that depressed individuals reported experiencing more negative events than did nondepressed individuals (e.g., Bylsma et al., 2011; Ravindran, Griffiths, Waddell, & Anisman, 1995; for an exception, see Peeters et al., 2003). It is important that depression status predicted instability of NA above and beyond frequency of experienced negative events. In addition, depression status predicted instability of NA even after controlling for the frequency with which participants experienced positive events, the intensity of the positive and negative events, and individuals' NA and PA reactivity to negative events. Because we assessed individuals' subjective reports of the events' intensity, we cannot rule out the possibility that the depressed participants rated the intensity of comparable events more negatively than did the controls. Future research should collect additional information that would allow raters to code the events.

The finding that MDD is not characterized by unchanging, chronically high NA has important clinical implications for the treatment of this disorder. In addition to understanding the factors that precede changes in clients' emotions, which is common in cognitive behavior therapies, these results suggest that special attention should be paid to the level of their emotional instability. Focusing on instability is particularly important given findings from recent approaches to intervention (e.g., acceptance and commitment therapy) documenting that emotional instability is related to the frequency with which individuals use maladaptive emotion regulation strategies, which could lead to the experience of additional stressors (Gratz & Tull, 2010).

The second aim of this study was to examine the relations among emotional instability, inertia, and reactivity, three facets of emotional experiences that have remained largely separate in psychological research. To our knowledge, only one other study has examined the relation between emotional instability and inertia. Similar to Jahng et al. (2008), we did not find evidence of a linear relation between instability and inertia of NA; instead, we found a quadratic relation between these two constructs. More specifically, and partially supporting our hypothesis, there was a trend for emotional instability to be inversely related to emotional inertia at high but not low levels. Notably, this is the first ESM study to examine the relation between emotional inertia and MDD in clinically depressed individuals; previous work has examined less severe forms of psychological maladjustment such as low self-esteem or high depressive symptoms.

Autocorrelations for both the depressed and nondepressed groups were in the .20 range, indicating that neither group had high inertia or was characterized by predictable emotions. We had hypothesized that individuals with MDD would have lower levels of NA inertia than would nondepressed individuals, but found that the two groups of participants did not differ in NA inertia. It is important to note that investigators have not yet developed calculations to determine the power needed for models as complicated as those used to assess inertia (e.g., Maas & Hox, 2005; Nezlek, in press; Richter, 2006; Scherbaum & Ferreter, 2009). Instead, researchers rely on general recommendations from simulation studies based on simple models examining cross-level interactions, such as the "50/20" rule (Hox, 1998), which recommends 20 Level 1 observations nested within 50 Level 2 units. Although according to this recommendation our sample had adequate power to test a simple cross-level interaction, there is not a clear rule for complex multilevel models (Snijders, 2005). Nevertheless, the confidence intervals suggest that our findings are unlikely to be due to a Type II error.

Our results are not consistent with Kuppens et al.'s (2010; Study 2) findings that MDD is characterized by high levels of emotional inertia or greater resistance to change. Because there are numerous differences between the design and samples of our study and those of Kuppens et al., the reasons for the discrepant findings are unclear. Whereas our sample was composed of adults who reported their subjective emotional experiences while engaging in a range of naturalistic everyday activities, some social and others not, Kuppens et al. had raters code the affect of adolescents who were engaged in a structured task (i.e., discussing a disagreement with a parent) in a laboratory setting. Thus, it is possible that depressed adolescents have higher levels of inertia of NA and PA than do depressed adults, or that inertia is related to activity type. Another notable difference was the time frame in which inertia was examined.

This study is also the first to examine the relation between emotional reactivity and emotional instability. As we expected, emotional reactivity to positive and negative external events was positively associated with emotional instability. Moreover, whereas reactivity of NA was associated with instability of NA, reactivity of PA was associated with instability of PA. Although our data did not support the tenets of ECI theory, we did replicate Bylsma et al.'s (2011) findings that depressed individuals reported greater decreases in NA to positive events than did healthy controls. Because both studies controlled for mean levels of NA over the week and at the previous prompt, this finding is not due to depressed individuals having higher baseline levels of NA. Thus, there is growing evidence for a mood-brightening effect in MDD.

Our finding that depressed and nondepressed individuals did not differ in their instability of PA is consistent with results reported by Peeters et al. (2006). These findings were obtained despite that depressed individuals reported significantly lower mean levels of PA than did healthy controls. In addition, consistent with our hypotheses, instability of PA and inertia of PA were inversely related.

The importance of PA in depression has gained increasing attention and empirical support (for a review, see Garland et al., 2010). For example, experiencing PA in the face of negative events has been found to be associated with decreased levels of NA (e.g., Wichers, Jacobs, Derom, Thiery, & van Os, 2007). Indeed, in this study we found that individuals with MDD reported lower levels of PA than did healthy controls and, further, that depression status accounted for approximately 10% of the overall variance of PA. It is important that investigators continue to examine the role of PA in the maintenance of MDD.

Integrating our findings within this study, and consistent with our hypotheses, we found that depressed and nondepressed individuals differed in their levels of emotional instability. In contrast to our own and others' predictions (e.g., Koval & Kuppens, 2011; Kuppens et al., 2010), depressed and nondepressed individuals did not differ significantly in their levels of inertia. Instead, depressed and nondepressed individuals' emotions were similarly resistant to change. Thus, temporal dependency (i.e., inertia) did not differentiate depressed individuals from healthy controls. This is particularly important because temporal dependency is an important facet of emotional instability (Jahng et al., 2008). Consequently, our findings suggest that depressed and nondepressed individuals are differentiated not by the temporal dependency component of emotional instability but by another important facet, variance. Our findings suggest that although reactions to significant external events contribute to emotional instability, these reactions or the frequency and intensity of the events do not fully explain the level of emotional instability in depressed individuals. Also important to note is neither do mean levels of NA. More research is required to elucidate mechanisms that underlie emotional instability in MDD.

We theorized that the relation between MDD and emotional instability is driven in part by correlates of emotional instability: interpersonal impairment and difficulties in emotion regulation. We also posited that negative cognitive biases that are associated with MDD will influence the relation between MDD and emotional instability (see Gotlib & Joormann, 2010, for a review). Future research is needed to examine explicitly whether interpersonal and cognitive impairments, as well as difficulties in emotion regulation, contribute to the association between MDD and emotional instability.

In closing, we note four limitations of this study. First, we used self-report to assess affect, which is subject to floor and ceiling effects. Nevertheless, evidence from the residual analyses indicated that neither group had a floor effect in their variability of NA or PA. Second, the affect items used in this study do not represent the full affective circumplex as it is often administered in other experience sampling research (e.g., Pietromonaco & Barrett, 2009), nor did we assess physiological indices (Ebner-Priemer & Trull, 2009). Third, our results may not generalize to older adults, who have been documented to be less emotionally labile than are younger adults (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000). Finally, because our comparison sample was composed of healthy controls, our data cannot speak to the specificity of the obtained findings to MDD. Other investigators have examined the relations between affective instability and borderline personality disorder and MDD (e.g., Ebner-Priemer et al., 2007; Trull et al., 2008). Future research should examine whether individuals with MDD differ in emotional instability, inertia, and reactivity from individuals with other mental health disorders that have been characterized by difficulties in the regulation of emotion (e.g., generalized anxiety disorder; Mennin, Heimberg, Turk, & Fresco, 2005).

Despite these limitations, however, these findings represent an important contribution to depression literature by examining, for the first time, how diagnosed depressed individuals differ from healthy controls with respect to several aspects of the temporal dynamics of emotion. The results of this study provide a more nuanced picture of the everyday emotional experiences of individuals with MDD. It is important to note that using a method with high ecological validity, the present findings elucidate facets of emotional experiences that are common to, and that differentiate, depressed and nondepressed individuals. Finally, these findings underscore the promise and importance of integrating distinct but conceptually related aspects of emotional functioning.

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