Emotion dynamics concurrently and prospectively predict mood psychopathology

By: Sarah H. Sperry, Molly A. Walsh, and Thomas R. Kwapil

Sperry, S.H., Walsh, M.A., & Kwapil, T.R. (2020). Emotion dynamics concurrently and prospectively predict mood psychopathology. *Journal of Affective Disorders, 261,* 67-75. https://doi.org/10.1016/j.jad.2019.09.076

Abstract:

Introduction: Altered emotion dynamics may represent a transdiagnostic risk factor for mood psychopathology. The present study examined whether altered emotion dynamics were associated with bipolar and depressive psychopathology concurrently and at a three-year follow-up. **Methods:** At baseline (n = 138), participants completed diagnostic interviews, questionnaires, and seven days of experience sampling assessments. Four emotion dynamics were computed for negative affect (NA) and positive affect (PA) – within-person variance (variability), mean square of successive differences and probability of acute change (instability), and autocorrelation (inertia). At the three-year follow-up, participants (n = 108) were re-assessed via interviews and questionnaires. **Results:** NA variability was associated with bipolar spectrum disorders at baseline and follow-up. NA instability predicted depressive symptoms and hypomanic personality at baseline, and bipolar spectrum disorders at the follow-up. NA inertia did not predict diagnoses or symptoms at either assessment. PA inertia predicted hyperthymic temperament at baseline but not follow-up. Notably, NA variability and instability predicted the development of new bipolar spectrum disorders at the follow-up. **Limitations:** Consistent with the recruitment strategy and young age of the participants, only 50% had developed diagnosable psychopathology by the time of the follow-up assessment. **Conclusions:** The present study provided a unique demonstration that altered emotion dynamics differentially predicted bipolar and depressive psychopathology concurrently and prospectively. Emotion dynamics are important to both digital phenotyping and mobile-based interventions as emotional instability offers a measurable risk factor that is identifiable prior to illness onset.

Keywords: Emotion dynamics | Instability | Bipolar | Depression | Experience sampling methodology | Time series analysis

Article:

Davidson (2015) proposed that temporal dynamics of emotional responding reflect particular chronometric parameters (e.g., rise time to peak and duration) following an affective provocation. Davidson's *affective chronometry* and the modern-day study of *emotion dynamics* posit that emotions represent dynamic and time-dependent phenomenon (Larsen et al., 2009; Lewis, 2005; Scherer, 2009) that fluctuate as a result of internal and external events (Fridja, 2007) and are distinct from mean levels of emotions (Eaton and Funder, 2001; Kuppens et al., 2007; Larsen, 1987; Penner et al., 1994; Sperry and Kwapil, 2019). Emotion

dynamics are proposed to precede and prospectively predict psychopathology and functioning over-and-above mean levels (Kuppens et al., 2012; Neumann et al., 2011; van de Leemput et al., 2014). In fact, emotion dynamics may play a key role in the development of psychopathology and exert cumulative effects on psychological well-being (Wichers et al., 2015). Thus, the study of emotion dynamics should further our understanding of basic emotional processing in mood psychopathology and may also inform preventative interventions.

Emotional variability, instability, and inertia are emotion dynamics that are widely linked to psychopathology. Variability represents the extent to which a persons emotions deviate away from their core or baseline emotion. Thinking mathematically, high variability reflects a large amplitude or standard deviation in emotional responses. Variability is captured by examining the standard deviation, or *within-person variance* (WPV), of each persons individual emotion ratings over the time-series (Eid and Diener, 1999; Jahng et al., 2008). Instability, as opposed to variability, represents the extent to which emotions change or fluctuate from one moment to the next. Mathematically, instability represents the amplitude, frequency, and temporal dependency of fluctuations in a persons emotions (Jahng et al., 2008). Instability can be measured several ways; however, the most common method of measurement is computing the *mean square of successive differences* (MSSD) which provides a general index of moment-to-moment fluctuations in emotion. However, it may be important to understand fluctuations in specific emotions or directions of change. For example, in bipolar spectrum psychopathology, individuals are more likely to engage in impulsive behaviors following an increase in negative (NA) and positive affect (PA; Sperry et al., 2016). Thus, Probability of Acute Change (PAC) can be calculated to examine whether an individual's instability is characterized by dramatic, or statistically significant, increases in certain emotions (e.g., large increases in NA from one moment to the next). In contrast to high variability and instability, some people experience inert emotions. Specifically, their emotions are largely resistant to change (Thompson et al., 2012). Alternatively, high levels of inertia can also reflect individuals who are emotionally reactive but fail to down-regulate and return to their baseline affect (Koval et al., 2015). Inertia is best measured as the autocorrelation (ACORR) of people's emotions from one moment to the next.

Despite advances in the modeling and computation of emotion dynamics, few studies have examined the concurrent or prospective associations of altered variability, instability, and inertia with psychopathology. A recent meta-analysis suggested that both major depressive disorder and borderline personality disorder are characterized by altered emotion dynamics; however, little is known about these processes in bipolar disorders (Houben et al., 2015). Understanding emotion dynamics within dynamic conditions such as bipolar disorders and major depressive disorder is essential for establishing digital phenotypes and the development of mobile or in-person interventions for emotion dysregulation.

1. Bipolar spectrum disorders

Patients with bipolar disorders are described as having “chaotic” patterns of mood (Gottschalk et al., 1995). Affective lability is present both as part of active episodes and during times of symptom remission (Hofmann and Meyer, 2006), predicts poor functioning, and is associated with the development of bipolar disorders (Angst et al., 2003; Hafeman et al., 2017; Henry et al., 2008). Nevertheless, few studies have examined altered emotion dynamics in

the bipolar spectrum. Previous studies have largely examined broader shifts between mood episodes, rather than moment-to-moment dynamics. For example, studies examining the statistical patterns of depressive and manic symptoms over time reported that bipolar I disorder was characterized by highly non-linear time-series (Bonsall et al., 2012; Cochran et al., 2016; Steinacher and Wright, 2013). Specifically, weekly depression scores across 220 weeks were highly variable and could not be predicted by the prior week's symptoms (Bonsall et al., 2012). Furthermore, bipolar I disorder was associated with high variability (Tsanas et al., 2016), high instability, and low levels of inertia of depressive and manic symptoms (Johnson and Nowak, 2002). Notably, instability of depressive symptoms in those with bipolar spectrum disorders was associated with slower recovery from rewarding or frustrating events (Steinacher and Wright, 2013), suicidal ideation (Armey et al., 2015; Johnson and Nowak, 2002), lower likelihood of and longer time until recovery (Stange et al., 2016), and negative biases in categorization and memory (Bilderbeck et al., 2016). Furthermore, hidden Markov modeling identified a “mixed” group of bipolar patients that experienced more temporally unstable mood and negative outcomes (e.g., psychosis, substance use, rapid cycling; Prisciandaro et al., 2018). Importantly, mood instability in both adults (Szmulewicz et al., 2019) and adolescents with bipolar spectrum psychopathology predicts worse outcomes (O'Donnell et al., 2018).

Sperry and Kwapil (2019) examined short-term dynamics of moment-to-moment emotions (high and low arousal NA and PA) associated with bipolar spectrum psychopathology over seven days. Bipolar spectrum psychopathology, as measured by the Hypomanic Personality Scale (HPS; Eckblad and Chapman, 1986), refers to a range of subclinical and clinical symptoms and impairment associated with mania. Bipolar spectrum psychopathology was associated with high variability and instability (both MSSD and PAC) of NA and PA. HPS scores were unassociated with emotional inertia. Taken together, this suggests that bipolar spectrum disorders and subclinical manifestations of bipolar spectrum psychopathology may be characterized by both short and long-term altered emotion dynamics prior to the onset of the disorder and between mood episodes.

2. Major depressive disorder

Major depressive disorder is characterized by high mean NA and low mean PA (e.g., Watson et al., 1988). Thus, prior research on emotion dynamics has primarily reported that people with major depressive disorder and those with elevated symptoms of depression show high levels of NA and PA inertia (Houben et al., 2015; Koval et al., 2013; Kuppens et al., 2012). Importantly, emotional inertia of both NA and PA predicted higher levels of rumination (Koval et al., 2012), lower well-being (Houben et al., 2015), and the emergence of clinical depression two years later (Kuppens et al., 2012). Recent studies also reported associations of high variability of NA and PA in daily life with major depressive disorder and current depressive symptoms. Specifically, studies indicated that depressive symptoms are associated with greater NA reactivity to positive events (Thompson et al., 2012) and variability of NA and PA (Houben et al., 2015; Koval et al., 2013; Thompson et al., 2017), indicating that people experiencing depressive symptoms may be characterized by heightened reactivity of NA and subsequently fail to down-regulate their affect. Furthermore, emotional variability in major depressive disorder has been linked with poor treatment response and outcomes (Husen et al., 2016; Wichers et al., 2012). Note that major

depressive disorder generally is unassociated with instability of NA or PA (Köhling et al., 2016; Koval et al., 2013).

3. Goals and hypotheses

Increasing evidence suggests that altered emotion dynamics represent a transdiagnostic risk factor for mood psychopathology. However, patterns of emotion dynamics may be qualitatively and quantitatively distinct across different forms of psychopathology. Few studies to date have examined whether altered emotion dynamics uniquely predict continuous and categorical measures of mood psychopathology concurrently or whether they predict symptoms and the development of diagnoses over time. The study of both continuous and categorical measures of psychopathology is important as modern research emphasizes a dimensional rather than categorical approach to conceptualizing psychopathology (Forbes et al., 2016; Kotov et al., 2017; Krueger and Piasecki, 2002; Lahey et al., 2017). Importantly, we aimed to capture the full spectrum of bipolar spectrum psychopathology by assessing severe/clinically impairing bipolar spectrum disorders as defined by the DSM-IV-TR (American Psychiatric Association, 2000), subthreshold but impairing bipolar psychopathology as defined by Akiskal's broad bipolar disorders (Akiskal, 2004), and the personality disposition of having hypomanic tendencies as defined by the Hypomanic Personality Scale (HPS; Eckblad and Chapman, 1986) and the Temperament Evaluation of Memphis, Pisa, Paris, and San Diego Autoquestionnaire (TEMPS-A; Akiskal et al., 2005; Akiskal and Akiskal, 2005). Thus, the goals of the present study were to examine the extent to which specific emotion dynamics differentially predict bipolar and depressive psychopathology both concurrently and prospectively three-years later. Specifically, we were interested in how the emotion dynamics of variability, instability, and inertia predicted (1) categorical and continuous measures of bipolar and depressive psychopathology at baseline and three-years later, and (2) development of new disorders at follow-up.

We hypothesized that variability and instability of NA and PA, but not inertia of NA or PA, would be associated with DSM-IV-TR bipolar disorders (bipolar I disorder, bipolar II disorder, cyclothymia, and bipolar not otherwise specified), Akiskal's broad bipolar diagnoses (bipolar II-½, bipolar III, bipolar IV, hyperthymic temperament), history of hypomanic episodes, and continuous measures of bipolar spectrum psychopathology (HPS; TEMPS-A hyperthymic temperament) both concurrently and three-years later. Furthermore, we predicted that instability of NA and PA would predict development of new bipolar spectrum diagnoses. Based on the extant literature, we predicted that variability and inertia of NA and PA would be associated concurrently and three years later with major depressive episodes, major depressive disorder, and continuous measures of depressive symptoms. Furthermore, we predicted that emotional inertia would specifically be associated with the development of major depressive diagnoses at the three-year follow-up.

4. Methods

4.1. Participants

4.1.1. Baseline assessment

Participants in the study were drawn from a longitudinal investigation of bipolar spectrum psychopathology. All participants completed a baseline assessment (Walsh et al., 2013, 2012a, 2012b). Participants were recruited through mass-screening in introductory psychology courses. Participants who scored at least 1.5 SD above the mean on the HPS and a comparable number who scored less than 1.5 SD above the mean were invited to participate. This recruitment strategy ensured a continuous distribution of scores on the HPS that was enriched with high scorers. Of the 147 participants who completed the baseline assessment, 138 had usable ESM data. Two participants were dropped from the study due to invalid HPS protocols and seven were omitted from analyses due to a insufficient number of completed ESM questionnaires (<15 completed surveys). Demographic characteristics of the baseline and follow-up samples are reported in Table 1.

Table 1. Demographics.

Baseline Assessment Criteria	**Baseline Assessment (*n* = 138)**	**Follow-up (*n* = 108)**
Symptom Ratings (M, SD)		
HPS score	19.81 (10.15)	–
Hyperthymic temperament	5.61 (3.49)	5.89 (3.86)
Beck Depression Inventory	4.33 (5.75)	–
Brief Symptom Inventory - Depression	–	0.45 (0.61)
Global Assessment of Functioning	75.97 (12.62)	73.90 (11.54)
Demographics		
Age *(M, SD)*	19.50 (2.34)	22.61 (2.61)
Years of Education (*M, SD)*	12.35 (0.78)	15.30 (0.94)
% Female	69	68
% White/Caucasian	67	65
% Black/African American	16	18
% Asian	4	5
% Hispanic	4	5
% Other	4	4
% Unspecified	5	5

Table 2. Diagnoses by assessment.

Baseline Diagnostic Status	**Diagnostic Status at Baseline**		**Diagnostic Status at Follow-up**	
	All participants (*n* = 138)	**Participants reassessed (*n* = 108)**	**Participants reassessed (*n* = 108)**	**New cases at follow-up**
DSM Bipolar Disorders	15 (10.9%)	12 (11.1%)	12 (11.1%)	0
Broad Bipolar Disorders	22 (15.8%)	18 (16.7%)	17 (15.7%)	4
Hypomania	14 (10.1%)	11 (10.2%)	14 (13%)	3
Major Depressive Episode	42 (30.4%)	36 (33.3%)	48 (44.4%)	10
Major Depressive Disorder	28 (20.3%)	24 (22.2%)	24 (22.2%)	7

New cases at follow-up represents new cases for those of which had no history of any diagnosis at baseline. Thus, new cases at follow-up does not add up to the difference between diagnostic status at follow-up and diagnostic status at baseline.

4.1.2. Follow-up assessment

A total of 112 participants (77% of original sample) were reassessed 3.1 years later (SD = 0.5 years; Range = 1.7 – 4.8 years). See Walsh et al. (2015) for details regarding participants lost to attrition. Of those participants who had usable ESM data at baseline (>15 surveys completed), 108 completed the follow-up assessment. Both assessments were approved by the university institutional review board. Participants provided informed consent at each assessment. They

received course credit for the baseline assessment and were paid for participation at the follow-up. Diagnostic status at the baseline assessment, follow-up, and development of new diagnoses are presented in Table 2.

4.2. Materials and procedures

4.2.1. Mass-screening questionnaires

Approximately 1,200 college students completed the HPS intermixed with a 13-item infrequency scale (Chapman & Chapman, 1983) in mass screenings. Coefficient α for the HPS was 0.92. Participants who endorsed more than two infrequency items were not considered for the study.

4.2.2. Structured interview

The interview at the baseline assessment assessed DSM-IV-TR mood disorders and broader bipolar spectrum disorders (see Walsh et al., 2015, 2012a, 2012b for complete list of interview measures). Interviews were conducted by two advanced psychology graduate students under the supervision of a licensed psychologist. One-fifth of the interviews were double rated to assess interrater reliability. The Structured Clinical Interview for the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (SCID-I; First et al., 1996) was used to assess current and past mood disorders. Broader bipolar spectrum disorders were diagnosed using the criteria from Akiskal (2004): the SCID-I Interview was used to determine diagnoses of bipolar II ½ (major depression superimposed on cyclothymic temperament) and III (major depression plus hypomania secondary to medication or somatic treatment) disorders, and interview ratings of hyperthymic temperament were used to determine diagnoses of bipolar IV disorder (major depression superimposed on hyperthymic temperament).

The same interview protocol was used at the follow-up to assess DSM-IV-TR mood disorders and bipolar spectrum disorders. Interviews were conducted by an advanced graduate student, a licensed clinical psychologist, and an extensively trained undergraduate researcher. The interviews at both assessments were audio recorded and typically lasted 90 to 120 min.

4.2.3. Continuous measures of psychopathology

At the baseline assessment, participants completed self-report questionnaires. The HPS was re-administered at the baseline assessment to examine stability from mass-screening to the time of the baseline assessment. HPS scores correlated highly across the two time points (ICC = 0.85, $p < 0.001$); therefore, mean HPS scores were used for all analyses. The HPS was not re-administered at the follow-up. The Beck Depression Inventory (BDI; Beck et al., 1961) was used to assess current depressive symptoms. The 50-item Temperament Evaluation of Memphis, Pisa, Paris, and San Diego Autoquestionnaire (TEMPS-A; Akiskal et al., 2005; Akiskal and Akiskal, 2005) provided a continuous rating of hyperthymic temperament. At the follow-up, the Brief Symptom Inventory Depression Index (Derogatis, 1993) was used to assess current depressive symptoms. The TEMPS-A was also re-administered at the follow-up assessment.

4.2.4. ESM questionnaire

The ESM questionnaire was designed to assess experiences relevant to bipolar spectrum psychopathology. After the interview at the baseline assessment, participants received a personal digital assistant (PDA) and were instructed on ESM procedures. ESM questionnaires were delivered eight times daily between noon and midnight for seven days. PDAs administered the questionnaires, time stamped, and recorded responses. Participants had three minutes to initiate a response. Two primary indices were computed and used for the present study, NA (irritable, sad, worried, angy) and PA (happy, enthusiastic, energetic). Internal consistency reliability was calculated using multilevel confirmatory factor analysis (Geldhof et al., 2014). The NA index showed good within-person reliability ($\omega = 0.74$) and excellent between-person reliability ($\omega = 0.93$). The PA index showed good within-person reliability ($\omega = 0.70$) and excellent between-person reliability ($\omega = 0.92$).

4.3. Computation of emotion dynamics

Emotion dynamics can be modeled across many timescales (moment-to-moment, day-to-day, week-to-week, etc.). The present study modeled emotion dynamics from moment-to-moment rather than day-to-day or week-to-week. Measurements of moment-to-moment dynamics, however, were aggregated across days. Note that in order to capture moment-to-moment dynamics within-days we did not calculate successive differences from the last beep of the prior day and the first beep of the following day. Emotion dynamic indices for variability, instability, and inertia (WPV, MSSD, PAC and ACORR) were computed in RStudio (Version 1.1.456) as follows:

4.3.1. Within person variance (WPV)

WPV was computed as the standard deviation of each participant's PA and NA ratings (Eid and Diener, 1999; Jahng et al., 2008) across questionnaires. Each participant was assigned one WPV value for NA (WPV_{NA}) and PA (WPV_{PA}).

4.3.2. Mean square of successive differences (MSSD)

First, separate lag variables ($time_i$ and $time_{i+1}$) were created for NA, PA, and time ESM questionnaires were completed. This allowed for the computation of a variable, time between ESM questionnaires that is necessary for the computation of MSSD. Second, we calculated successive differences between emotions at $time_i$ and $time_{i+1}$ separately for NA and PA. Based on Jahng et al. (2008), we adjusted each successive difference to account for unevenly spaced time by dividing it by $[(t_{i+1} - t_i)/Mdn(t_{i+1} - t_i)]^{\lambda}$ where $Mdn(t_{i+1}-t_i)$ is the median of the time intervals for each i for each participant. One Lambda (λ) value was chosen to make successive difference as constant as possible for all participants. Then, adjusted successive differences were square and used in the equation for calculating MSSD for each participant as defined in Eq. (1):

$$MSSD = \frac{1}{N-1}\sum_{i=1}^{N-1}(x_{i+1} - x_i)^2 \quad (1)$$

Higher MSSD values represent more emotional instability. Each participant has one MSSD value for NA ($MSSD_{NA}$) and PA ($MSSD_{PA}$).

4.3.3. Probability of acute change (PAC)

PAC was computed as the number of acute changes divided by the total changes across all ESM occasions for each participant (Jahng et al., 2008). First, we standardized the successive differences across the sample. Second, we assessed whether successive differences represented a meaningful increase. Following Jahng et al. (2008), Trull et al. (2008), and Sperry & Kwapil (2019), we selected acute cutoff (AC) values of the 90th percentile for the sample. PAC was computed as the proportion of changes that were acute increases for each participant. Higher PAC scores represent higher levels of acute instability. Each participant has one value of PAC for NA (PAC_{NA}) and PA (PAC_{PA}).

4.3.4. Autocorrelation (ACORR)

Autocorrelation is used to assess emotional inertia (Jahng et al., 2008; Kuppens et al., 2010). Autocorrelation coefficients, or ACORR(*h),* in which *h* represents the time lag between signals, were computed with a lag of one (e.g., examining the extent to which NA at time *t* is correlated with NA at time *t + 1*). High values of ACORR represent resistance to change or inertia (high temporal dependency), whereas low scores indicate low temporal dependency. ACORR(1) values were computed using the auto-covariance/correlation function estimation of the Sapply package (Venables and Ripley, 2002) in R. Each participant has one value of ACORR for NA ($ACORR_{NA}$) and PA ($ACORR_{PA}$).

Data from the first ESM protocol of each day was not included in the computation of MSSD and ACORR so that indices did not include differences between the last protocol of the prior day and the first protocol of the following day. In instances of missing data, successive differences were not calculated and were viewed as missing. We also examined the extent to which number of missing surveys was correlated with any predictor or outcome variables in the study. Number of missing ESM surveys was unassociated with all continuous and categorical measures with the excpection of the HPS (r=−0.28, p = .01). Note that data, R code, and templates are provided at: https://osf.io/x59rh/?view_only=80481c6b8cb74d37aaa3211414979e09

5. Results

In order to examine the association of emotion dynamics and bipolar and depressive psychopathology, binary logistic regression was computed for dichotomous measures (e.g., DSM bipolar diagnosis) and linear regression was used for continuous measures (e.g., HPS). In order to examine whether emotion dynamics predicted the development of *new* diagnoses at the follow-up, we calculated the number of new disorders in those who had no diagnosis at the baseline assessment (n = 59; see Table 2). Thus, these analyses examined whether emotion dynamics at the baseline assessment predicted the development of new cases three years later in initially non-diagnosed participants. Note that for all analyses predicting follow-up psychopathology, we re-ran analyses controlling for baseline mood psychopathology.

6. Variability of emotions and psychopathology

In terms of categorical diagnoses, WPV_{NA} was assocated with broad bipolar disorders at the baseline assessment and predicted DSM-IV-TR bipolar disorders and hypomania at the follow-up (Table 3). However, WPV_{NA} was no longer associated with DSM bipolar disorders at the follow-up when controlling for these diagnoses at baseline (OR = 1.75, 95%CI [.80, 3.83], $p = .16$). WPV_{PA} was associated with a history of hypomania at baseline but did not predict any diagnoses at the follow-up (Table 4). In terms of continuous measures of psychopathology, WPV_{NA} was associated with hypomanic personality and depression at the baseline assessment and predicted hyperthymic temperament at the follow-up (Table 5). However, WPV_{NA} no longer predicted hyperthymic temperament at the follow-up after controlling for baseline hyperthymic temperament ($t(87) = 0.89$, $p = .38$). WPV_{PA} was unassociated with continuous measures of mood psychopathology at both baseline and follow-up (Table 6). Neither WPV_{NA} nor WPV_{PA} predicted the development of new disorders at the follow-up (Table 7).

Table 3. Association of NA emotion dynamics and categorical outcomes at baseline and follow-up.

	WPV_{NA}		**$MSSD_{NA}$**		**PAC_{NA}**	
	Baseline ($n = 138$)	**Follow-up ($n = 108$)**	**Baseline ($n = 138$)**	**Follow-up ($n = 108$)**	**Baseline ($n = 138$)**	**Follow-up ($n = 108$)**
Outcome	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**
DSM_BD	1.64 [.95, 2.83]	2.07 [1.12, 3.83]*	1.16 [.71, 1.89]	1.45 [.91, 2.32]	1.29 [.77, 2.17]	1.50 [.85, 2.67]
Broad_BD	1.63 [1.02, 2.61]*	1.44 [.87, 2.38]	1.17 [.77, 1.78]	1.54 [1.00, 2.38]*	1.13 [.72, 1.77]	1.75 [1.05, 2.92]*
Hypomania	1.63 [.93, 2.85]	1.89 [1.07, 3.33]*	1.15 [.69, 1.91]	1.41 [.90, 2.21]	1.30 [.76, 2.21]	1.54 [.90, 2.65]
MDE	1.21 [.84, 1.74]	1.34 [.92, 1.96]	1.37 [.96, 1.96]	1.39 [.94, 2.04]	1.25 [.86, 1.80]	1.08 [.74, 1.58]
MDD	1.03 [.68, 1.56]	.87 [.56, 1.36]	1.36 [.93, 2.00]	.88 [.55, 1.40]	1.36 [.91, 2.04]	.72 [.44, 1.17]

Note. DSM_BD = DSM Bipolar Disorder, Broad_BD = Broad Bipolar Disorders, MDE = Major Depressive Episode, MDD = Major Depressive Disorder.
*p <. 05 **p < .01 ***p < .001.

Table 4. Association of PA emotion dynamics and categorical outcomes at baseline and follow-up.

	WPV_{PA}		**$MSSD_{PA}$**		**PAC_{PA}**	
	Baseline ($n = 138$)	**Follow-up ($n = 108$)**	**Baseline ($n = 138$)**	**Follow-up ($n = 108$)**	**Baseline ($n = 138$)**	**Follow-up ($n = 108$)**
Outcome	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**
DSM_BD	1.55 [.92, 2.61]	1.61 [.89, 2.92]	1.34 [.84, 2.12]	1.71 [.99, 2.96]	1.00 [.58, 1.71]	1.15 [.62, 2.11]
Broad_BD	1.25 [.80, 1.96]	1.20 [.71, 2.01]	1.28 [.85, 1.93]	1.91 [1.14, 3.18]*	1.15 [.74, 1.78]	1.87 [1.11, 3.15]*
Hypomania	1.75 [1.03, 2.99]*	1.42 [.81, 2.48]	1.29 [.80, 2.09]	1.52 [.89, 2.58]	.82 [.45, 1.51]	.95 [.52, 1.74]
MDE	1.07 [.74, 1.53]	1.26 [.85, 1.87]	1.24 [.87, 1.76]*	1.67 [1.05, 2.68]*	1.08 [.75, 1.54]	1.27 [.84, 1.91]
MDD	1.09 [.72, 1.65]	.85 [.53, 1.37]	1.25 [.85, 1.83]	.63 [.34, 1.19]	.92 [.60, 1.41]	.70 [.41, 1.20]

Note. DSM_BD = DSM Bipolar Disorder, Broad_BD = Broad Bipolar Disorders, MDE = Major Depressive Episode, MDD = Major Depressive Disorder.
*p < .05 **p < .01 ***p < .001.

Table 5. Association of NA emotion dynamics and continuous outcomes at baseline and follow-up.

	WPV_{NA}		$MSSD_{NA}$		PAC_{NA}	
	Baseline (*n* = 138)	**Follow-up (*n* = 108)**	**Baseline (*n* = 138)**	**Follow-up (*n* = 108)**	**Baseline (*n* = 138)**	**Follow-up (*n* = 108)**
Outcome	***β***	***β***	***β***	***β***	***β***	***β***
Hypomanic Personality	.35***	–	.22**	–	.29***	–
Hyperthymic Temperament	.16	.22*	.11	.20*	.24*	.19*
Depression	.29***	.11	.18*	.02	.17*	.05

*$p < .05$ **$p < .01$ ***$p < .001$.

Table 6. Association of PA emotion dynamics and continuous outcomes at baseline and follow-up.

	WPV_{PA}		$MSSD_{PA}$		PAC_{PA}	
	Baseline (*n* = 138)	**Follow-up (*n* = 108)**	**Baseline (*n* = 138)**	**Follow-up (*n* = 108)**	**Baseline (*n* = 138)**	**Follow-up (*n* = 108)**
Outcome	***β***	***β***	***β***	***β***	***β***	***β***
Hypomanic Personality	.11	–	.21*	–	.20*	–
Hyperthymic Temperament	.01	.14	.07	.19*	.16	.19*
Depression	.01	−0.04	.11	.03	.00	.05

*$p < .05$ **$p < .01$ ***$p < .001$.

Table 7. Association of emotion dynamics with new diagnoses three years later.

	WPV OR [95% CI]	**MSSD OR [95% CI]**	**PAC OR [95% CI]**	**ACORR OR [95% CI]**
Negative Affect				
DSM_BD	1.46 [.54, 3.93]	1.58 [.79, 3.14]	1.57 [.63, 3.94]	.36 [.10, 1.27]
Broad_BD	1.80 [.93, 3.48]	2.06 [1.23, 3.45]**	2.45 [1.29, 4.66]**	.58 [.28, 1.18]
Hypomania	1.65 [.53, 5.19]	1.81 [.88, 3.71]	1.85 [.65, 5.28]	.34 [.08, 1.48]
MDE	1.13 [.63, 2.04]	.95 [.51, 1.76]	.75 [.39, 1.43]	.90 [.49, 1.65]
MDD	.93 [.51, 1.86]	.86 [.41, 1.76]	.56 [.25, 1.22]	.83 [.43, 1.60]
Positive Affect				
DSM_BD	1.25 [.48, 3.24]	1.44 [.66, 3.12]	1.00 [.58, 1.71]	.34 [.11, 1.03]
Broad_BD	1.55 [.84, 2.84]	1.85 [1.13, 3.04]*	1.73 [1.00, 3.01]	.94 [.49, 1.79]
Hypomania	.92 [.29, 2.96]	1.46 [.61, 3.50]	1.06 [.35, 3.23]	.11 [.02, 0.77]*
MDE	1.49 [.85, 2.63]	1.37 [.83, 2.25]	1.30 [.76, 2.24]	1.16 [.64, 2.13]
MDD	.89 [.46, 1.72]	.78 [.37, 1.69]	.87 [.44, 1.73]	1.36 [.70, 2.67]

Note. DSM_BD = DSM Bipolar Disorder, Broad_BD = Broad Bipolar Disorders, MDE = Major Depressive Episode, MDD = Major Depressive Disorder.
*$p < .05$ **$p < .01$ ***$p < .001$.

7. Instability of emotions and psychopathology

$MSSD_{NA}$ was unassociated with bipolar or depressive diagnoses at the baseline assessment, but predicted broad bipolar disorders at the follow-up (Table 3). This remained true after accounting for diagnoses at baseline (OR = 1.54, 95%CI [.99, 2.41], $p <$. 05). A similar pattern emerged for $MSSD_{PA}$ (Table 4). $MSSD_{PA}$ was associated with broad bipolar diagnoses and a history of major depressive episodes at the follow-up, even after controlling for baseline broad bipolar disorders (OR = 1.84, 95%CI [1.06, 3.19], $p <$. 05). The association of $MSSD_{PA}$ and major depressive episodes at follow-up was no longer significant after controlling for baseline major depressive episodes (OR = 2.12, 95%CI [.99, 4.55], p = .05). In terms of continuous measures, $MSSD_{NA}$ was

associated with hypomanic personality and depressive symptoms at baseline and hyperthymic temperament at the follow-up (Table 5). The association with hyperthymic temperament was no longer significant after accounting for baseline hyperthymic temperament ($t(87) = 0.69$, $p = .49$). $MSSD_{PA}$ was associated with hypomanic personality at baseline and hyperthymic temperament at the follow-up (Table 6). Similarly, this association was no longer significant after accounting for baseline hyperthymic temperament, ($t(87) = 1.35$, $p = .18$). Importantly, MSSD at baseline predicted the development of several diagnoses at the follow-up (Table 7) in participants without diagnoses at the baseline assessment. Both $MSSD_{NA}$ and $MSSD_{PA}$ predicted the development of broad bipolar disorders after three-years.

PAC_{NA} was unassociated with baseline mood diagnoses, but was associated with broad bipolar disorders at the follow-up (Table 3). This remained significant after accounting for diagnostic status at baseline (OR = 1.81, 95%CI [1.05, 3.13], $p < 0.05$). PAC_{PA} also continued to predict broad bipolar disorders three-years later (Table 4) after controlling for diagnostic status at baseline (OR = 1.87, 95%CI [1.07, 3.29], $p < 0.05$). Similar to MSSD, PAC_{NA} was associated with hypomanic personality, hyperthymic temperament, and depressive symptoms at baseline and predicted hyperthymic temperament at the follow-up (Table 5). After controlling for baseline hyperthymic temperament, PAC_{NA} was no longer associated with hyperthymic temperament three-years later ($t(87) = 0.62$, $p = .54$). PAC_{PA} predicted hypomanic personality at baseline and hyperthymic temperament at the follow-up (Table 6). Again, this association was no longer significant after accounting for baseline hyperthymic temperament ($t(87) = 0.49$, $p = .63$). PAC_{NA} predicted the development of new broad bipolar disorders at the follow-up (Table 7). PAC_{PA} did not predict the development of new diagnoses.

8. Inertia of emotions and psychopathology

Values of ACORR were largely unassociated with continuous and categorical measures of psychopathology or the development of new disorders (Table 7). The only significant finding was that lower levels of $ACORR_{PA}$ predicted increased hyperthymic temperament at the follow-up. This was no longer significant after accounting for baseline hyperthymic temperament. All results for ACORR can be found in Supplemental Table 1.

9. Post-hoc analyses

Recent research has highlighted the importance of understanding whether different indices of emotion dynamics provide unique information or are largely redundant. Dejonckheere et al. (2019) found that although some emotion dynamic indices provide unique predictive information, many dynamics are highly correlated and no longer predict psychological well-being after accounting for one-another as well as mean levels of NA and PA. Given these new findings, we ran several additional analyses. First, we report the correlation of all the NA and PA emotion dynamics, as well as mean NA and PA (Supplemental Table 2). Second, we re-ran all analyses entering in mean NA and PA, WPV, MSSD, PAC, and ACORR simultaneously to predict mood outcomes (see supplemental tables 3 – 6). In general, findings were difficult to interpret given the high multicollinearity between dynamic indices (e.g., several suppression effects were observed). For example, hypomanic personality was positively correlated with MSSD when MSSD was the sole predictor and negatively correlated

when emotion dynamics were entered as simultaneous predictors. However, in general, WPV became the most robust predictor of mood psychopathology over-and-above other emotion dynamics and mean levels.

10. Discussion

Modern approaches to the study of emotion suggest that the time-dependent fluctuations and patterns of emotional responding provide important information about intraindividual reactivity to one's environment. Altered emotion dynamics in daily life have been implicated in several forms of psychopathology (see Houben et al., 2015); however, few studies have examined associations between these processes and psychopathology cross-sectionally or longitudinally. The present study provided a unique examination of the extent to which specific emotion dynamics at a baseline assessment were differentially associated with bipolar and depressive psychopathology concurrently and three years later.

11. Bipolar spectrum psychopathology

Consistent with our hypotheses, bipolar spectrum psychopathology was associated both concurrently and prospectively with variability, instability, and probability of acute increases in NA and PA. Emotion dynamics were most robustly associated with broad bipolar disorder diagnoses and hypomanic personality. These findings indicate that broader bipolar phenotypes with more persistent courses (e.g., hyperthymic temperament, bipolar II ½) may be characterized by more moment-to-moment affective lability than more episodic courses (e.g., bipolar I disorder, bipolar II disorder). Note that variability of NA was the only emotion dynamic that predicted DSM bipolar diagnoses. It is unclear whether the lack of associations with DSM bipolar diagnoses was due to absence of association or lack of power as only 12 participants [11% of the sample] were diagnosed with a DSM bipolar disorder (which was not surprising given the young age of the sample and the fact that it contained participants who scored across the entire range on our measure of risk for bipolar psychopathology). Nevertheless, the finding of associations of emotion dynamics with bipolar symptoms and disorders in a non-clinically ascertained sample demonstrates that these dynamics are identifiable in non-disordered individuals and relevant to the development of such disorders. Notably, the present findings directly replicated those of Sperry & Kwapil (2019) that HPS scores were associated with WPV_{NA}, $MSSD_{NA}$ and $MSSD_{PA}$, and PAC_{NA} and PAC_{PA}.

Not only did variability and instability of NA and PA predict bipolar psychopathology at baseline and the three-year follow-up, these dynamics predicted development of new broad bipolar diagnoses. These findings are especially promising as a) emotional instability may be a unique risk factor for the development of bipolar spectrum psychopathology and b) real-world momentary assessments of emotions are associated with symptoms and impairment three-years later. Taken together, this suggests that assessment of emotional instability may facilitate identification of individuals at risk for bipolar disorders and provide a prophylactic treatment target that can be easily monitored using electronic devices.

12. Major depressive disorder and depressive symptoms

Major depressive disorder has traditionally been characterized by high levels of NA and low levels of PA (Watson et al., 1988). Furthermore, major depressive disorder and depressive symptoms are characterized by emotional inertia. In other words, people with depression experience fewer changes in their emotions from moment-to-moment. In contrast, recent studies have suggested that major depressive disorder is also associated with variability (Wichers et al., 2010) and instability (Thompson et al., 2012). This seems counter-intuitive given depression's strong association with emotional inertia. However, Koval et al. (2013) highlighted a potential mis-interpretation of these findings. First, studies that use WPV to calculate variability are not sufficient to determine whether a particular time-series is characterized by instability, as WPV only reflects experiencing a large range of emotion, not necessarily instability. Thus, studies need to examine MSSD, a measure of temporal dependency, to determine if this population truly experiences unstable emotions (e.g., Thompson et al., 2012). Second, in order to elucidate these paradoxical results, Koval et al. (2013) examined both short-term (seconds) and longer-term (hours) emotion dynamics as they related to depressive symptoms. When controlling for the statistical dependency within measures, depressive symptoms were solely associated with inertia in the lab, whereas in daily ESM data, depressive symptoms were solely associated with variability. This indicates that when looking in daily life on the scale of hours, depressive symptoms are related to more variability (larger SD) of NA, but not inertia.

In the present study, we found that altered emotion dynamics were unassociated with major depressive disorder and major depressive episodes either concurrently or prospectively. However, continuous measures of depressive symptoms were associated with variability and instability of NA and a higher probability of large increases in NA. Those experiencing depressive symptoms were characterized by a large overall range of NA (variability) that typically changed moment-to-moment (instability). Taken together this suggests that depressive symptoms were associated with moment-to-moment lability in terms of NA in a non-clinically ascertained sample. Contrary to previous findings, depressive symptoms and diagnoses were unassociated with emotional inertia. However, given the timescale that we used to sample emotions (hours over days), our findings are consistent
with Koval et al. (2013) and Thompson et al. (2012) who found no differences between depressed and healthy participants in terms of inertia in daily life. These results highlight the importance of considering timescale in the measurement of emotion dynamics (Ebner-Priemer and Sawitzki, 2007; Hollenstein, 2015).

13. Implications

This is the first study to our knowledge that examines both the concurrent and prospective prediction of symptoms and diagnoses by measures of emotion dynamics. Notably, daily life measures of emotion dynamics predicted symptoms and diagnoses three years later. These findings indicate, particularly for bipolar spectrum disorders, that emotional instability may be a measurable risk factor that is identifiable prior to illness onset or reccurence. However, in many cases, these associations were no longer significant after accounting for diagnostic status or symptom severity at baseline. This was mostly true for findings regarding hyperthymic temperament. Notably, in many cases, psychopathology was unassociated with hyperthymic temperament at the baseline assessment, so it may still be worthwhile to interpret initial findings without controlling for baseline hyperthymic temperament.

Recently, researchers have called into question whether measuring multiple emotion dynamics is necessary, or whether specific emotion dynamic indices provide unique predictive validity over mean levels or variability. Following Dejonckheere et al. (2019), we re-ran all analyses with mean levels and each emotion dynamic entered simultaneously. As mentioned, these findings were difficult to interpret given high multicollinearity between predictors. Furthermore, it is unclear, after partialling all other dynamics, what is "left over" when examining the relationship between a specific emotion dynamic and mood psychopathology (see Lynam et al., 2006). Interestingly, WPV was the most robust concurrent predictor of bipolar spectrum psychopathology over-and-above both mean levels and other dynamics whereas mean levels were the most robust predictor of depressive symptoms. This was true for both NA and PA. Dejonckheere et al. (2019) found similar patterns in which mean NA was the most robust predictor of depressive psychopathology and WPV of NA was the most robust predictor of borderline personality disorder. These findings potentially suggest that for those high in bipolar spectrum psychopathology, the range in intensity of emotions experienced is more problematic than having deviations away from core emotion on a moment-to-moment basis, although this should be interpreted with caution.

Two recommendations are offered based on the present findings. First, phone-based apps that aim to characterize psychopathology and etiology should specifically examine moment-to-moment fluctuations in NA and PA in addition to mood (mania and depression) symptoms. Although passive ambulatory data collection is less burdensome, accurate self-reports of emotions require the use of active data collection. Thus, efforts to characterize emotional instability in bipolar spectrum disorders and major depressive disorder should use both active and passive data collection. Second, phone-based interventions for bipolar spectrum disorders should specifically aim to use evidenced-based principles to target emotion dysregulation (e.g., Dialectical Behavior Therapy) when individuals are experiencing altered emotion dynamics even outside the context of mood episodes (see Wright et al., 2018 for a good example of such an effort).

These findings provide further support for a model of bipolar spectrum psychopathology in which both subsyndromal and clinical manifestations are associated with symptoms and impairment in daily life. In this study, we used well-validated measures including DSM-IV-TR bipolar diagnoses, Akiskal's broad bipolar disorders, and personality-based measurues of bipolar spectrum psychopathology to capture this spectrum. However, DSM and Akiskal's disorders are categorical in nature, potentially limiting our ability to capture an inherently continuous phenomenon (Ahmed et al., 2011; Prisciandaro and Tolliver, 2015). Thus, the importance of developing continuous measurement systems for bipolar spectrum psychopathology will be essential for understanding the full bipolar phenotype.

14. Limitations

The present study relied on previously collected data that did not have the original goal of examining emotion dynamics. Given this, the NA and PA indices developed from the ESM questionnaire had less coverage of the full affective circumplex than desired (e.g., both high and low arousal NA and PA). Studies of emotion dynamics should examine both levels of valence

and arousal as differences may exist across forms of psychopathology in terms of valence-arousal disruptions (Sperry and Kwapil, 2019). Furthermore, the present study's primary goal was to examine the expression, identification, and development of bipolar spectrum psychopathology in a non-clinical sample in a relatively young sample. Given this, the sample was limited in the number of participants who had thus far developed bipolar disorders. Future studies interested in examining differential patterns of emotion dynamics as they relate to multiple forms of psychopathology should recruit samples that have a) a range of symptoms and impairment across forms of psychopathology and b) high numbers of those experiencing clinical levels of psychopathology. This will enable further investigations into whether alterations in emotion dynamics quantitatively and qualitatively differs depending on severity of bipolar spectrum psychopathology.

Given the ESM questionnaire and procedures, the present findings highlight dynamics *within* emotional valence categories (NA vs. PA). It is likely also interesting to examine the extent to which individuals experience biphasic fluctuations in daily life (PA to NA and vis versa). Thus, future research should examine a) the extent to which individuals on the bipolar spectrum experience NA and PA as bipolar or interdependent (see Russell and Caroll, 1999; Dejonckheere et al., 2018) and b) whether individuals experience lability in terms of biphasic shifts between NA and PA.

15. Conclusion

Altered emotion dynamics may represent a transdiagnostic risk factor for mood symptoms and impairment. However, the present study indicated that differential patterns of emotion dynamics may be associated with unique forms of psychopathology. Major depressive disorder and depressive symptoms seem to be associated with emotional lability in the context of NA. Furthermore, bipolar spectrum psychopathology was robustly associated with variability, instability, and a probability of acute increases in NA and PA both concurrently, longitudinally, and with the development of new disorders. The modeling of emotion dynamics in psychopathology is a promising method for characterizing real-world emotional processing, can be done using personal smartphones, and offers an important target for intervention, especially in bipolar spectrum disorders.

Contributors. Molly Walsh and Tom Kwapil designed the initial study. Sarah Sperry developed the research idea and hypotheses, completed the literature searches, and undertook the statistical analyses. Sarah Sperry wrote the first draft of the manuscript. Thomas Kwapil and Molly Walsh contributed to all subsequent versions of the manuscript and approved the final version.

Funding. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest. Sarah Sperry, Molly Walsh, and Thomas Kwapil have no conflicts of interest to report.

Acknowledgements. There are no acknowledgements to report.

Supplementary materials. Supplementary material associated with this article can be found at doi:10.1016/j.jad.2019.09.076.

References

Ahmed, A.O., Green, B.A., Clark, C.B., Stahl, K.C., McFarland, M.E.,., 2011. Latent structure of unipolar and bipolar mood symptoms. Bipolar Disord. 13 (5–6), 522–536. https://doi.org/10.1111/j.1399-5618.2011.00940.x.

Akiskal, H.S., 2004. The bipolar spectrum in psychiatric and general medical practice. Prim. Psychiatry 11, 30–35.

Akiskal, H.S., Mendlowicz, M.V., Jean-Louis, G., Rapaport, M.H., Kelsoe, J.R., Gillin, J.C., Smith, T.L., 2005. TEMPS-A: validation of a short version of a self-rated instrument designed to measure variations in temperament. J. Affect. Disord. 85, 45–52. https://doi.org/10.1016/J.JAD.2003.10.012.

Akiskal, K.K., Akiskal, H.S., 2005. The theoretical underpinnings of affective temperaments: implications for evolutionary foundations of bipolar disorder and human nature. J. Affect. Disord. 85, 231–239. https://doi.org/10.1016/J.JAD.2004.08.002.

American Psychiatric Association, 2000. Diagnostic and Statistical Manual of Mental Disorders, 4th ed. American Psychiatric Association, Washington, DC test revision.

Angst, J., Gamma, A., Endrass, J., 2003. Risk factors for the bipolar and depression spectra. Acta Psychiatr. Scand. 108, 15–19. https://doi.org/10.1034/j.1600-0447.108.s418.4.x.

Armey, M.F., Schatten, H.T., Haradhvala, N., Miller, I.W., 2015. Ecological momentary assessment (EMA) of depression-related phenomena. Curr. Opin. Psychol. 4, 21–25. https://doi.org/10.1016/J.COPSYC.2015.01.002.

Beck, A.T., Ward, C.H., Mendelson, M., Mock, J., Erbaugh, J., 1961. An inventory for measuring depression. Arch. Gen. Psychiatry 4, 561–571. https://doi.org/10.1001/archpsyc.1961.01710120031004.

Bilderbeck, A.C., Reed, Z.E., McMahon, H.C., Atkinson, L.Z., Price, J., Geddes, J.R., Goodwin, G.M., Harmer, C.J., 2016. Associations between mood instability and emotional processing in a large cohort of bipolar patients. Psychol. Med. 46, 3151–3160. https://doi.org/10.1017/S003329171600180X.

Bonsall, M.B., Wallace-Hadrill, S.M.A., Geddes, J.R., Goodwin, G.M., Holmes, E.A., 2012. Nonlinear time-series approaches in characterizing mood stability and mood instability in bipolar disorder. Proc. R. Soc. B Biol. Sci. 279, 916–924. https://doi.org/10.1098/rspb.2011.1246.

Cochran, A.L., McInnis, M.G., Forger, D.B., 2016. Data-driven classification of bipolar I disorder from longitudinal course of mood. Transl. Psychiatry 6, e912. https://doi.org/10.1038/tp.2016.166.

Davidson, R.J., 2015. Comment: affective chronometry has come of age. Emot. Rev. 7, 368–370. https://doi.org/10.1177/1754073915590844.

Dejonckheere, E., Mestdagh, M., Houben, M., Erbas, Y., Pe, M., Koval, P., Brose, A., Bastian, B., Kuppens, P., 2018. The bipolarity of affect and depressive symptoms. J. Pers. Soc. Psychol. 114 (2), 323–341. https://doi.org/10.1037/pspp0000186.

Dejonckheere, E., Mestdagh, M., Houben, M., Rutten, I., Sels, L., Kuppens, P., Tuerlinckx, F., 2019. Complex affect dynamics add limited information to the prediction of psychological well-being. Nat. Hum. Behav. 1.

Derogatis, L., 1993. Brief Symptom Inventory: Administration, scoring, and Procedures Manual, 4th ed. National Computer Systems, Minneapolis, MN.

Eaton, L.G., Funder, D.C., 2001. Emotional experience in daily life: valence, variability, and rate of change. Emotion 1, 413.

Ebner-Priemer, U.W., Sawitzki, G., 2007. Ambulatory assessment of affective instability in borderline personality disorder. Eur. J. Psychol. Assess. 23, 238–247. https://doi.org/10.1027/1015-5759.23.4.238.

Eckblad, M., Chapman, L.J., 1986. Development and validation of a scale for hypomanic personality. J. Abnorm. Psychol. 95, 214.

Eid, M., Diener, E., 1999. Intraindividual variability in affect: reliability, validity, and personality correlates. J. Pers. Soc. Psychol. 76, 662.

First, M.B., Spitzer, R., Gibbon, M., Williams, J., 1996. Structured Clinical Interview for Axis I Disorders-Patient Edition. Biometrics Research, New York State Psychiatric Institute, New York.

Forbes, M.K., Tackett, J.L., Markon, K.E., Krueger, R.F., 2016. Beyond comorbidity: toward a dimensional and hierarchical approach to understanding psychopathology across the life span. Dev. Psychopathol. 28, 971–986.

Fridja, N.H., 2007. The Laws of Emotion. Lawrence Erlbaum Associates Publishers, Mahway, NJ, US.

Geldhof, G.J., Preacher, K.J., Zyphur, M.J., 2014. Reliability estimation in a multilevel confirmatory factor analysis framework. Psychol. Methods 19, 72–91. https://doi.org/10.1037/a0032138.

Gottschalk, A., Bauer, M.S., Whybrow, P.C., 1995. Evidence of chaotic mood variation in bipolar disorder. Arch. Gen. Psychiatry 52, 947. https://doi.org/10.1001/archpsyc.1995.03950230061009.

Hafeman, D., Merranko, J., Goldstein, T., Axelson, D., Goldstein, B., Monk, K., Hickey, M., Sakolsky, D., Diler, R., Iyengar, S., Brent, D., Kupfer, D., Kattan, M., Birmaher, B., 2017. Assessment of a person-level risk calculator to predict new-onset bipolar spectrum disorder in youth at familial risk. JAMA Psychiatry 74, 841–847.

Henry, C., Van den Bulke, D., Bellivier, F., Roy, I., Swendsen, J., M'Baïlara, K., Siever, L.J., Leboyer, M., 2008. Affective lability and affect intensity as core dimensions of bipolar disorders during euthymic period. Psychiatry Res. 159, 1–6.

Hofmann, B.U., Meyer, T.D., 2006. Mood fluctuations in people putatively at risk for bipolar disorders. Br. J. Clin. Psychol. 45, 105–110.

Hollenstein, T., 2015. This time, it's real: affective flexibility, time scales, feedback loops, and the regulation of emotion. Emot. Rev. 7, 308–315. https://doi.org/10.1177/1754073915590621.

Houben, M., Van Den Noortgate, W., Kuppens, P., 2015. The relation between short-term emotion dynamics and psychological well-being: a meta-analysis. Psychol. Bull. 141, 901.

Husen, K., Rafaeli, E., Rubel, J.A., Bar-Kalifa, E., Lutz, W., 2016. Daily affect dynamics predict early response in CBT: feasibility and predictive validity of EMA for outpatient psychotherapy. J. Affect. Disord. 206, 305–314. https://doi.org/10.1016/j.jad.2016.08.025.

Jahng, S., Wood, P.K., Trull, T.J., 2008. Analysis of affective instability in ecological momentary assessment: indices using successive difference and group comparison via multilevel modeling. Psychol. Methods. https://doi.org/10.1037/a0014173.

Johnson, S.L., Nowak, A., 2002. Dynamical patterns in bipolar depression. Personal. Soc. Psychol. Rev. 6, 380–387. https://doi.org/10.1207/S15327957PSPR0604_12.

Köhling, J., Moessner, M., Ehrenthal, J.C., Bauer, S., Cierpka, M., Kämmerer, A., Schauenburg, H., Dinger, U., 2016. Affective instability and reactivity in depressed patients with and without borderline pathology. J. Pers. Disord.

Kotov, R., Krueger, R.F., Watson, D., Achenbach, T.M., Althoff, R.R., Bagby, R.M., Brown, T.A., Carpenter, W.T., Caspi, A., Clark, L.A., Eaton, N.R., Forbes, M.K., Forbush, K.T., Goldberg, D., Hasin, D., Hyman, S.E., Ivanova, M.Y., Lynam, D.R., Markon, K., Miller, J.D., Moffitt, T.E., Morey, L.C., Mullins-Sweatt, S.N., Ormel, J., Patrick, C.J., Regier, D.A., Rescorla, L., Ruggero, C.J., Samuel, D.B., Sellbom, M., Simms, L.J., Skodol, A.E., Slade, T., South, S.C., Tackett, J.L., Waldman, I.D., Waszczuk, M.A., Widiger, T.A., Wright, A.G.C., Zimmerman, M., 2017. The hierarchical taxonomy of psychopathology (HiTOP): a dimensional alternative to traditional nosologies. J. Abnorm.Psychol. 126, 454–477. https://doi.org/10.1037/abn0000258.

Koval, P., Brose, A., Pe, M.L., Houben, M., Erbas, Y., Champagne, D., Kuppens, P., 2015. Emotional inertia and external events: the roles of exposure, reactivity, and recovery. Emotion 15, 625.

Koval, P., Kuppens, P., Allen, N.B., Sheeber, L., 2012. Getting stuck in depression: the roles of rumination and emotional inertia. Cogn. Emot. 26, 1412–1427. https://doi.org/10.1080/02699931.2012.667392.

Koval, P., Pe, M.L., Meers, K., Kuppens, P., 2013. Emotion affect dynamics in relation to depressive symptoms: variable. Unstable or Inert?. https://doi.org/10.1037/a0033579.

Krueger, R.F., Piasecki, T.M., 2002. Toward a dimensional and psychometrically-informed approach to conceptualizing psychopathology. Behav. Res. Ther. 40, 485–499.

Kuppens, P., Allen, N.B., Sheeber, L.B., 2010. Emotional inertia and psychological maladjustment. Psychol. Sci. 21, 984–991.

Kuppens, P., Sheeber, L.B., Yap, M.B.H., Whittle, S., Simmons, J.G., Allen, N.B., 2012. Emotional inertia prospectively predicts the onset of depressive disorder in adolescence. Emotion 12, 283.

Kuppens, P., Van Mechelen, I., Nezlek, J.B., Dossche, D., Timmermans, T., 2007. Individual differences in core affect variability and their relationship to personality and psychological adjustment. Emotion 7, 262.

Lahey, B.B., Krueger, R.F., Rathouz, P.J., Waldman, I.D., Zald, D.H., Author, P.B., 2017. A hierarchical causal taxonomy of psychopathology across the life span hhs public access author manuscript. Psychol. Bull. 143, 142–186. https://doi.org/10.1037/bul0000069.

Larsen, R.J., 1987. The stability of mood variability: a spectral analytic approach to daily mood assessments. J. Pers. Soc. Psychol. 52, 1195.

Larsen, R.J., Augustine, A.A., Prizmic, Z., 2009. A process approach to emotion and personality: using time as a facet of data. Cogn. Emot. 23, 1407–1426.

Lewis, M.D., 2005. Bridging emotion theory and neurobiology through dynamic systems modeling. Behav. Brain Sci. 28, 169–194.

Lynam, D.R., Hoyle, R.H., Newman, J.P., 2006. The perils of partialling: cautionary tales from aggression and psychopathy. Assessment 13, 328–341. https://doi.org/10.1177/1073191106290562.

Neumann, A., Van Lier, P.A.C., Frijns, T., Meeus, W., Koot, H.M., 2011. Emotional dynamics in the development of early adolescent psychopathology: a one-year longitudinal study. J. Abnorm. Child Psychol. 39, 657–669. https://doi.org/10.1007/s10802-011-9509-3.

O'Donnell, L.A., Ellis, A.J., Van de Loo, M.M., Stange, J.P., Axelson, D.A., Kowatch, R.A., Schneck, C.D., Miklowitz, D.J., 2018. Mood instability as a predictor of clinical and functional outcomes in adolescents with bipolar i and bipolar ii disorder multifaceted investigations of the neurobiology of depression subtypes view project depakote view project mood instability as a predictor of clinical and functional outcomes in adolescents with bipolar I and bipolar II disorder. Artic. J. Affect. Disord. 236, 199–206. https://doi.org/10.1016/j.jad.2018.04.021.

Penner, L.A., Shiffman, S., Paty, J.A., Fritzsche, B.A., 1994. Individual differences in intraperson variability in mood. J. Pers. Soc. Psychol. 66, 712.

Prisciandaro, J.J., Tolliver, B.K., 2015. Evidence for the continuous latent structure of mania and depression in out-patients with bipolar disorder: results from the systematic treatment enhancement program for bipolar disorder (STEP-BD). Psychol. Med. 45 (12), 2595–2603.

Prisciandaro, J.J., Tolliver, B.K., DeSantis, S.M., 2018. Identification and initial validation of empirically derived bipolar symptom states from a large longitudinal dataset: an application of hidden Markov modeling to the systematic treatment enhancement program for bipolar disorder (STEP-BD) study. Psychol. Med. 1–7. https://doi.org/10.1017/S0033291718002143.

Russell, J.A., Carroll, J.M., 1999. On the bipolarity of positive and negative affect. Psych. Bull. 125, 3–30. https://doi.org/10.1037/0033-2909.125.1.3.

Scherer, K.R., 2009. The dynamic architecture of emotion: evidence for the component process model. Cogn. Emot. 23, 1307–1351.

Sperry, S.H., 2016. Examining the role of impulsivity in bipolar spectrum psychopathology: identification and expression in daily life (Masters thesis. Univ. NorthCarolina Greensboro).

Sperry, S.H., Kwapil, T.R., 2019. Affective dynamics in bipolar spectrum psychopathology: modeling inertia, reactivity, variability, and instability in daily life. J. Affect. Disord. https://doi.org/10.31234/osf.io/rcg93.

Stange, J.P., Sylvia, L.G., da Silva Magalhães, P.V., Miklowitz, D.J., Otto, M.W., Frank, E., Yim, C., Berk, M., Dougherty, D.D., Nierenberg, A.A., Deckersbach, T., 2016. Affective instability and the course of bipolar depression: results from the STEP-BD randomised controlled trial of psychosocial treatment. Br. J. Psychiatry 208, 352–358. https://doi.org/10.1192/bjp.bp.114.162073.

Steinacher, A., Wright, K.A., 2013. Relating the bipolar spectrum to dysregulation of behavioural activation: a perspective from dynamical modelling. PLoS ONE 8, e63345. https://doi.org/10.1371/journal.pone.0063345.

Szmulewicz, A.G., Martino, D.J., Strejilevich, S.A., 2019. Characterization of mood instability through bipolar disorders: a cluster-analytic approach using weekly prospective life-chart methodology. Eur. Psychiatry 57, 52–57. https://doi.org/10.1016/j.eurpsy.2018.10.003.

Thompson, R.J., Boden, M.T., Gotlib, I.H., 2017. Emotional variability and clarity in depression and social anxiety. Cognit. Emot. 31, 98–108. https://doi.org/10.1080/02699931.2015.1084908.

Thompson, R.J., Mata, J., Jaeggi, S.M., Buschkuehl, M., Jonides, J., Gotlib, I.H., 2012. The everyday emotional experience of adults with major depressive disorder: examining emotional instability, inertia, and reactivity. J. Abnorm. Psychol. 121, 819–829. https://doi.org/10.1037/a0027978.

Tsanas, A., Saunders, K.E.A., Bilderbeck, A.C., Palmius, N., Osipov, M., Clifford, G.D., Goodwin, G.M., De Vos, M., 2016. Daily longitudinal self-monitoring of mood variability in bipolar disorder and borderline personality disorder. J. Affect. Disord. 205, 225–233. https://doi.org/10.1016/J.JAD.2016.06.065.

van de Leemput, I.A., Wichers, M., Cramer, A.O.J., Borsboom, D., Tuerlinckx, F., Kuppens, P., van Nes, E.H., Viechtbauer, W., Giltay, E.J., Aggen, S.H., 2014. Critical slowing down as early warning for the onset and termination of depression. Proc. Natl. Acad. Sci. 111, 87–92.

Venables, W.N., Ripley, B.D., 2002. Random and Mixed Effects. Springer, New York, NY, pp. 271–300. https://doi.org/10.1007/978-0-387-21706-2_10.

Walsh, M.A., Brown, L.H., Barrantes-Vidal, N., Kwapil, T.R., 2013. The expression of affective temperaments in daily life. J. Affect. Disord. 145, 179–186. https://doi.org/10.1016/J.JAD.2012.07.026.

Walsh, M.A., Royal, A., Brown, L.H., Barrantes-Vidal, N., Kwapil, T.R., 2012a. Looking for bipolar spectrum psychopathology: identification and expression in daily life. Compr. Psychiatry 53, 409–421. https://doi.org/10.1016/J.COMPPSYCH.2011.06.006.

Walsh, M.A., Royal, A.M., Barrantes-Vidal, N., Kwapil, T.R., 2012b. The association of affective temperaments with impairment and psychopathology in a young adult sample. J. Affect. Disord. 141, 373–381. https://doi.org/10.1016/J.JAD.2012.03.016.

Watson, D., Clark, L.A., Carey, G., 1988. Positive and negative affectivity and their relation to anxiety and depressive disorders. J. Abnorm. Psychol. 97, 333–346.

Wichers, M., Lothmann, C., Simons, C.J.P., Nicolson, N.A., Peeters, F., 2012. The dynamic interplay between negative and positive emotions in daily life predicts response to treatment in depression: a momentary assessment study. Br. J. Clin. Psychol. 51, 206–222. https://doi.org/10.1111/j.2044-8260.2011.02021.x.

Wichers, M., Peeters, F., Geschwind, N., Jacobs, N., Simons, C.J.P., Derom, C., Thiery, E., Delespaul, P.H., van Os, J., 2010. Unveiling patterns of affective responses in daily life may improve outcome prediction in depression: a momentary assessment study. J. Affect. Disord. 124, 191–195. https://doi.org/10.1016/J.JAD.2009.11.010.

Wichers, M., Wigman, J.T.W., Myin-Germeys, I., 2015. Micro-level affect dynamics in psychopathology viewed from complex dynamical system theory. Emot. Rev. 7, 362–367. https://doi.org/10.1177/1754073915590623.

Wright, K., Dodd, A., Warren, F.C., Medina-Lara, A., Taylor, R., Jones, S., Owens, C., Javaid, M., Dunn, B., Harvey, J.E., Newbold, A., Lynch, T., 2018. The clinical and cost effectiveness of adapted dialectical behaviour therapy (DBT) for bipolar mood instability in primary care (ThrIVe-B programme): a feasibility study. Trials 19, 560. https://doi.org/10.1186/s13063-018-2926-7.