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RESEARCH ARTICLE

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Real-time assessment of positive and negative affective fluctuations and mood lability in a transdiagnostic sample of youth

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Abstract

Background: Emotional lability, defined as rapid and/or intense affect fluctuations, is associated with pediatric psychopathology. Although numerous studies have examined labile mood in clinical groups, few studies have used real-time assessments in a well-characterized transdiagnostic sample, and no prior study has included participants with disruptive mood dysregulation disorder (DMDD). The present study leverages ecological momentary assessment (EMA) to assess emotional lability in a transdiagnostic pediatric sample.

Methods: One hundred thirty participants ages 8–18 with primary diagnoses of DMDD, attention-deficit/hyperactivity disorder (ADHD), an anxiety disorder (ANX), or healthy volunteers completed a previously validated 1-week EMA protocol. Clinicians determined diagnoses based on semi-structured interviews and assessed levels of functional impairment. Participants reported momentary affective states and mood change. Composite scores of fluctuations in positive and negative affect were generated. Affect fluctuations were compared between diagnostic groups and tested for their association with functional impairment.

Results: Diagnostic groups differed in levels of negative and positive emotional lability. DMDD patients demonstrated the highest level of labile mood compared with other groups. Emotional lability was associated with global impairment in the whole sample.

Conclusions: Both positive and negative emotional lability is salient in pediatric psychopathology and is associated with functional impairment, particularly in DMDD youth.

KEYWORDS

anxiety, attention-deficit/hyperactivity disorder, disruptive mood dysregulation disorder, ecological momentary assessment, emotional lability

1 | INTRODUCTION

Emotional lability is a characteristic of most pediatric psychopathology and is associated with increased impairment (Beauchaine, 2015; Bunford et al., 2018; Silk et al., 2003; Stringaris & Goodman, 2009). Although not a diagnostic criterion, emotional lability has been documented in depression, anxiety, and attention-deficit/hyperactivity disorder (ADHD) and it is a transdiagnostic risk factor for general psychopathology (Beauchaine & Cicchetti, 2019; Karalunas et al., 2019). However, research has primarily relied on retrospective report (Kim-Spoon et al., 2013; Sobanski et al., 2010; Stringaris & Goodman, 2009), on negative valenced emotional dysregulation (Rydell et al., 2003; Sobanski et al., 2010), and has yet to include severely irritable youth. The present study leverages real-time ecological momentary assessment (EMA) to examine emotional lability in a pediatric sample across several clinical diagnoses. Specifically, we focused on clinical diagnoses associated with emotion dysregulation including ADHD, anxiety, and disruptive mood dysregulation disorder (DMDD).

Emotion dysregulation has been reported in ADHD youth (e.g., Kim-Spoon et al., 2013; Rosen et al., 2015). One study found high emotional lability was associated with a higher prevalence of ADHD symptoms, such as hyperactivity-impulsivity, oppositionality, and substance abuse (Sobanski et al., 2010). Interestingly, emotional lability was not merely an aspect of an ADHD diagnosis, as 70% of the variance in labile mood could not be explained by ADHD symptom severity. Another study reported on three types of ADHD: mild, surgent with extreme positive approach-motivation, and irritable with extreme negative emotionality (Karalunas et al., 2014). Later work also found that irritability and surgency are as strongly related to the risk for ADHD as core ADHD symptoms (Nigg et al., 2020). Both studies suggest that positive and negative valenced emotions are central to ADHD, although further research on these fluctuations is needed.

In addition to ADHD, emotion dysregulation has also been reported in anxiety (e.g., Maire et al., 2017; Schoevers et al., 2021; Tan et al., 2012). One study of emotional lability in adult patients with psychopathology found that those with current anxiety or depression diagnoses had the highest positive and negative emotional lability when compared to other diagnostic groups (Schoevers et al., 2021). Similarly, in youth, a study of preschoolers found that increased emotional lability was associated with higher psychopathology, including anxiety (Maire et al., 2017). After controlling for covariates, including other psychopathology and demographic variables, emotional lability remained significantly associated with anxiety and hyperactivity-impulsivity symptoms.

Clinical conceptualizations of DMDD focus on persistent irritability as a core symptom, suggesting consistently elevated negative affect (Brotman et al., 2017; Roy et al., 2014). DMDD youth frequently experience irritable and frustrated affective states, which are often intense and labile (Martin et al., 2017). Dougherty et al. (2014) demonstrated that DMDD is associated with teachers' reports of intense negative affect in children. Though irritability is a manifestation of emotional lability, most of the existing studies explored negative emotional intensity and emotional reactivity in DMDD rather than fluctuations in affect (Dougherty et al., 2014; Martin et al., 2017; Mulraney et al., 2021). The current study addresses this gap in current knowledge by exploring daily fluctuations in affect in DMDD as measured in a naturalistic setting. Critically, this is the first study we are aware of that includes prospective clinical data and compares different pediatric psychiatric disorders to explore daily emotional lability in a naturalistic setting.

While most of the research has focused on dysregulation of negative valenced emotions (Rydell et al., 2003; Sobanski et al., 2010), recent studies suggest that aberrant shifting of positive emotions (Rydell et al., 2003; Schoevers et al., 2021) is a critical component in adolescent psychopathology (Gilbert, 2012; Rydell et al., 2003; Schoevers et al., 2021), and is associated with impulsivity and externalizing problems (Cole et al., 1994; Rothbart & Jones, 1998; Rydell et al., 2003; Vogel et al., 2019). One study of preschoolers (Rydell et al., 2003) found negative and positive emotional lability to predict different psychological problems; with increased negative emotional lability predicting externalizing and internalizing behaviors while increased positive emotional lability predicts lower levels of prosocial behavior. Another study on emotion regulation among youth showed that both negative and positive emotional lability predict social-emotional difficulties, particularly in youth with comorbid ADHD and oppositional defiant disorder (ODD) compared to ADHD alone (Silverman et al., 2022). Similarly, in preschool-aged youth, Vogel and colleagues (Vogel et al., 2019) found that both positive and negative lability were uniquely associated with later psychopathology and dysfunction. While positive lability predicted worse global functioning through adolescence, and later lability and negativity in mood, negative lability predicted worse global functioning through late childhood. However, the exact contribution of positive and negative labile mood to impairment in pediatric populations needs to be explored further. Thus, the current study explores both positive and negative fluctuations in affect and their association with impairment across different clinical diagnoses.

Standard retrospective ratings are valuable for capturing emotional and behavioral tendencies but are also limited by reporters' cognitive biases and heuristics (Ebner-Priemer & Trull, 2009). These capture average behavior over weeks or months rather than granular, dynamic shifts in emotions. While these measures have a well-established place in research, other methods are needed to capture in vivo affective dynamics. EMA is one tool that can encapsulate these shifts, yet few studies have leveraged EMA to evaluate pediatric emotional lability, with the majority focusing solely on negative emotional lability (Leaberry et al., 2020) and within one specific diagnostic group such as ADHD (Slaughter et al., 2020), anxiety (Tan et al., 2012), or depression (Silk et al., 2011). Overall, these studies show an association between real-time emotional lability and clinical symptom severity, with clinical groups demonstrating elevated emotional lability compared to controls (Factor et al., 2014; Schoevers et al., 2021). In our current work we leveraged EMA to assess and compare real-time emotional lability patterns across

groups and examine positive affect's potential unique role to impairment.

Our transdiagnostic pediatric sample included diagnoses of DMDD, ADHD, anxiety disorders (ANX), and healthy volunteers (HV). We had two main aims. First, we compared levels of emotional lability across diagnostic groups. We hypothesized that clinical youth would present elevated levels of positive and negative emotional lability compared to HV, as well as more shifts between these states (conceptualized as mood change). We also hypothesized that DMDD and ADHD participants would experience greater positive and negative emotional lability, compared to ANX participants, due to emotional intensity being an inherent aspect of these disorders (Dougherty et al., 2014; Sobanski et al., 2010). Second, we anticipated impairment would be associated with emotional lability. To capture lability in positive and negative emotional states, we replicated a method used in previous studies that measures affect fluctuations (e.g., Jahng et al., 2008; Schoevers et al., 2021) and implemented root mean successive squared difference scores (RMSSD) as a within-person variance measure (for more details: see Section 2).

2 | METHODS

2.1 | Participants

One hunderd and thirty youth ages 8–18 (see Table 1 for sample characteristics) participated in the present study. Participants had a primary diagnosis of either DMDD ($N = 31$), ADHD ($N = 33$), anxiety (ANX; $N = 33$), and HV with no psychopathology (HV; $N = 33$). See Table 2 for psychiatric comorbidities. Participants were recruited through two separate IRB-approved research protocols (one that assessed ANX and HV and one that assessed DMDD and ADHD). They were combined for the purpose of this study to allow us to explore specific questions related to positive and negative lability. ANX and HV groups were randomly matched to the DMDD and

TABLE 1 Demographics ($N = 130$ youth)

Characteristic	Diagnostic group				
	Whole sample	DMDD ($N = 31$)	ADHD ($N = 33$)	ANX ($N = 33$)	HV ($N = 33$)
Age mean (SD)	12.55 (2.51)	12.38 (2.32)	12.70 (2.35)	12.67 (2.80)	12.45 (2.62)
Gender *N*, %					
Male	91, 70.00%	21, 67.70%	28, 84.80%	22, 66.70%	20, 60.60%
Female	39, 30.00%	10, 32.30%	5, 15.20%	11, 33.30%	13, 39.40%
Race *N*, %					
White/Caucasian	85, 65.40%	25, 80.60%	19, 57.60%	20, 60.60%	21, 63.60%
African American	13, 10.00%	3, 9.70%	4, 12.10%	1, 3.00%	5, 15.20%
Asian American	6, 4.60%	1, 3.20%	1, 3.00%	2, 6.10%	2, 6.10%
American Indian	3, 2.30%	0.00%	2, 6.10%	1, 3.00%	0.00%
Ethnicity *N*, %					
Latino/Hispanic	13, 10.00%	1, 3.20%	6, 18.20%	5, 15.20%	1, 3.00%
Not Latino/Hispanic	110, 84.60%	28, 90.30%	25, 75.80%	25, 75.80%	32, 97.00%
IQ mean (SD)	114.03 (12.06)	112.96 (10.44)	113.25 (12.73)	115.85 (11.90)	113.57 (13.31)
Medication *N*, %					
Psychotropic	42, 32.30%	26, 83.90%	16, 48.50%	–	–
Antidepressants	18, 13.80%	17, 54.80%	1, 3.00%	–	–
Stimulants	35, 26.90%	19, 61.30%	16, 48.50%	–	–
Non-stimulant	5, 3.80%	3, 9.70%	2, 6.10%	–	–
Mood stabilizers	1, 0.80%	1, 3.20%	0.00%	–	–
Atypical antipsychotics	5, 3.80%	5, 16.10%	0.00%	–	–
Anti-convulsant	2, 1.50%	2, 6.50%	0.00%	–	–

Note: Only DMDD and ADHD participants were medicated.

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ANX, anxiety disorder; DMDD, disruptive mood dysregulation disorder; HV, healthy volunteers.

TABLE 2 Psychiatric comorbidities

Diagnoses	Diagnostic group DMDD (*N* = 30)*	ADHD (*N* = 31)*	ANX (*N* = 33)
MDD history	3.20% (1)	0.00%	3.00% (1)
Panic disorder	0.00%	0.00%	6.10% (2)
Separation anxiety	12.90% (4)	12.10% (4)	33.30% (11)
Specific phobia	9.70% (3)	3.00% (1)	18.20% (6)
Social phobia	16.10% (5)	9.10% (3)	48.50% (16)
Agoraphobia	0.00%	0.00%	3.00% (1)
GAD	38.70% (12)	12.10% (4)	93.90% (31)
ADHD	77.40% (24)	100.00% (31)	3.00% (1)
CD	0.00%	3.00% (1)	0.00%
ODD**	–	27.30% (9)	0.00%
Tourette's	3.20% (1)	0.00%	0.00%
Chronic motor	6.50% (2)	0.00%	0.00%
Transient Tic	3.20% (1)	0.00%	0.00%
DMDD	100.00% (30)	0.00%	0.00%
Enuresis	12.90% (4)	3.00% (1)	3.00% (1)

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ANX, anxiety disorder; CD, conduct disorder; DMDD, disruptive mood dysregulation disorder; GAD, generalized anxiety disorder; MDD, major depressive disorder; ODD, oppositional defiant disorder.

*There is no comorbidity data for one DMDD participant and two ADHD participants so the data within this table presents only the participants with full KSADS-PL information.

**Based on DSM-5 guidelines, a DMDD diagnosis supersedes an ODD diagnosis so no information on the ODD and DMDD diagnostic overlap is provided.

ADHD groups based on age and sex. Diagnostic groups did not differ in terms of race (Likelihood ratio$_{(9)}$ = 8.71, p = .47), age ($F_{(3)}$ = 0.13, p = .95), sex ($F_{(3)}$ = 1.7, p = .17), IQ ($F_{(3)}$ = 0.36, p = .78), or ethnicity (Likelihood ratio$_{(3)}$ = 7.85, p = .05).

Participants were recruited via social media advertisements, clinician referrals, and postcards sent to surrounding cities. Masters or doctoral level clinicians completed the Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime version (KSADS-PL; Kaufman et al., 1997) to determine diagnoses and eligibility. Potential participants were excluded if they had an IQ below 70 as measured by the Wechsler abbreviated intelligence scale (Wechsler, 1999; see Wiggins et al., 2016 for full inclusion/exclusion criteria). ANX or HV participants were also excluded if they were taking any psychotropic medication (see Table 1 for medication information). DMDD and ADHD participants could be medicated during EMA. Comparing medication status between DMDD and ADHD yielded a significant difference ($\chi^2_{(1,\ N=64)}$ = 8.87, p = .003), with DMDD participants being more likely to be on medication (83.87%) than ADHD participants (48.48%).

Participants and their parents were informed that participation was voluntary, and they signed written assent and consent forms before enrollment. Participants were compensated for their participation. Study procedures were approved by NIMH IRB.

2.2 | Procedure

EMA data were collected between August 2017 and January 2021. Research assistants scheduled EMA trainings with participants and caregivers. Training sessions were standardized and were intended to familiarize families with the text messages and the hardware (i.e., cellphone). The EMA survey included 21 prompts (3 prompts per day for 7 days; for full description of EMA procedures see Naim et al., 2021). Following EMA, clinicians assessed global impairment using a clinician-rated questionnaire. Compensation was given to participants at the end of their participation, and participants that completed 75% or more of their surveys received an extra $10. Length of EMA period and number of prompts per day aligned with most EMA studies assessing mood symptoms (Hall et al., 2021).

Two participants were excluded from the analyses due to low EMA compliance rate (completed prompts N < 5). This threshold allows sufficient time points for within-person variability analyses and was determined based on commonly used standards in previous EMA studies (Wen et al., 2017) across both adults (Williams-Kerver et al., 2021) and youth (Russell & Gajos, 2020) samples, also consistent with prior work in our group (Naim et al., 2021; Smith et al., 2019). The mean compliance rate of the overall sample was 78.54% (SD = 16.38%), with all groups presenting high compliance rates (de Vries et al., 2021; Wrzus & Neubauer, 2022). Though the ANX group had significantly lower compliance rates compared to other diagnostic groups ($F_{(3)}$ = 3.32, p = .022), their compliance rate was still high (M = 71%, SD = 18%) and in line with previous studies including anxious participants (Morgan et al., 2017; Tan et al., 2012). Additional analyses revealed that the missing data was at random for EMA items of interest and that inclusion of the two participants below the compliance threshold did not significantly change the findings (see Supporting Information Material for a detailed description on these analyses).

During the COVID-19 pandemic (March 2020 to January 2021), EMA training sessions occurred remotely over a video platform (N = 19). Cellphones were mailed to participants as needed, and all other procedures mirrored prepandemic sessions (N = 117).

2.3 | Measures

2.3.1 | EMA items

Six EMA items were used to measure emotional lability.

Mood change, including changes between positive and negative emotional states, was assessed using the following item:

- Mood change: "Since the last beep, my mood changed a lot."

Positive emotional lability was assessed using two EMA items:

- Momentary happiness: "At the time of the beep, I felt happy."
- Momentary giddiness: "At the time of the beep, I felt much more giddy, silly, or happy than usual."

Negative emotional lability was assessed using three EMA items:

- Momentary anxiety: "At the time of the beep, I felt worried or scared."
- Momentary anger: "At the time of the beep, I felt annoyed or angry."
- Momentary unhappiness: "At the time of the beep, I felt unhappy, sad, or miserable."

Items were measured using a 5-point Likert scale (ranging from 1 "not at all" to 5 "extremely"). These EMA items have been previously examined by our group and shown to correlate with established gold-standard self-, parent-, and clinician-report measures (Naim et al., 2021; Smith et al., 2019). While most of these items were designed to capture affect in a more absolute sense, others (e.g., the giddiness item) were designed to capture how participants were feeling relative to their typical affective state. Including these two types of items allowed us to capture a variety of nuanced experiences in youth's daily life, including mood states that the participants identified as more extreme compared to their baseline. A composite score for each positive and negative component of emotional lability was generated using an unweighted average of all items in each category, followed by the computation of a RMSSD score.

2.3.2 | Generating composite scores for negative and positive affect

To generate composite scores for positive and negative emotional lability, we combined EMA items based on positive and negative affect categories. Our rationale was based on theoretical and empirical grounds supporting the generation of higher-order measures of affect, and specifically two-factor models that could better reflect affect categories and capture their internal content (Tuccitto et al., 2010). We also investigated our data based on our a-priori interest looking at positive versus negative daily fluctuations in youth. After generating composite scores of positive and negative affect fluctuations, we calculated RMSSD values to assess lability of affect. RMSSD is a valid measurement of affective instability and captures the magnitude and temporal dependency of affective fluctuations (Jahng et al., 2008; Schoevers et al., 2021). Larger values equate to higher variability in affect. RMSSD variables were calculated using the *Psych* package in R (Revelle, 2021).

Standardized betas from our multilevel modeling (MLM) were used to reflect the magnitude of within-person associations between items of interest. The positive emotion items included momentary happiness and momentary giddiness. The within-person association of these items ($\beta = .26$, $p < .001$) and between-person association of RMSSD values for these items ($r = .53$, $p < .001$) were significant. To generate a composite score of positive emotional lability, the average of the two RMSSD values was calculated for each participant. EMA items of interest for negative emotional lability were momentary anxiety, anger, and unhappiness. Intercorrelation between these items was found to be significant (momentary anxiety to momentary anger; $\beta = .11$, $p < .003$, momentary anger to momentary unhappiness; $\beta = .32$, $p < .001$, momentary anxiety to momentary unhappiness; $\beta = .18$, $p < .001$). Correlations between the variability scores of these items yielded higher magnitude of these associations (RMSSD anxiety to RMSSD anger; $r = .46$, $p < .001$, RMSSD anger to RMSSD unhappiness; $r = .63$, $p < .001$, RMSSD anxiety to RMSSD unhappiness; $r = .47$, $p < .001$). To generate a composite score of negative emotional lability, these RMSSD items were summed and divided by three.

We also assessed within- and between-person reliability using multilevel confirmatory factor analyses (MCFA) (Geldhof et al., 2014). We used the *lavaan* package in R (Rosseel, 2012) followed by the *semTools* package (Jorgensen et al., 2020) to extract multilevel reliabilities based on the fitted MCFAs. Loadings of the two items of the positive scores were fixed to equality. Focusing on omega parameter, within-person reliability was found to be medium across positive (0.40) and negative (0.54) factors, while between-person reliability was high for the negative factor (0.89) but low for the positive factor (0.22). In addition to reporting reliability scores for the whole sample, we have also generated these parameters specifically for the patient groups ($N = 97$, i.e., omitting the HV) based on the elevated variability in mood across the clinical diagnoses. Within-person reliability remain similar and medium in magnitude for the positive (0.41) and negative (0.55) factors. The between-person reliability for the positive factor was found to be higher in this subgroup of patients, and medium in magnitude (0.35). The between-person reliability for the negative factor remained similar and high (0.88).

See Supporting Information Material for description and results for daily level based RMSSD analyses.

2.3.3 | Clinical global impressions severity (CGI-S) scale

Global impairment was measured using the CGI-S scale (Busner & Targum, 2007). The CGI-S is a one-item measure delivered by an experienced clinician that rates psychopathology symptom severity on a scale from 1 to 7. The item is, "Considering your total clinical experience with this particular population, how mentally ill is the patient at this time?" The CGI-S has been shown to have good and established validity (Berk et al., 2008).

2.4 | Data analysis

Question 1a. *Do diagnostic groups vary in levels of mood change?* Due to the nested structure of the data (prompts within participants), MLM analyses for the current question were performed using HLM software (Raudenbush et al., 2019). A series of HLMs were conducted with Level-1, including the mood change item as the outcome measure (i.e., mean-as-outcome models). The mood change variable was continuous and person-centered. Level-2 included the uncentered categorical predictor of diagnostic groups that were dummy coded (0 = diagnosis not present; 1 = diagnosis present). The reference group in the equations was modified with each equation to allow comparisons among all diagnostic categories.

Question 1b. *Do diagnostic groups vary in levels of positive emotional lability?* We ran a one-way analysis of variance (ANOVA) in SPSS with the composite RMSSD positive emotional lability score as the dependent variable and diagnostic groups as the independent variable. For significant effects, pairwise post hoc analysis was applied using Fisher's least significant difference (LSD).

Question 1c. *Do diagnostic groups vary in levels of negative emotional lability?* We ran a one-way ANOVA in SPSS with the composite RMSSD negative emotional lability score as the dependent variable and diagnostic groups as the independent variable. For significant effects, pairwise post hoc analysis was applied using Fisher's LSD.

Question 2. *Is global impairment associated with emotional lability components?* A series of linear regression models were conducted with either mood change, positive emotional lability, or negative emotional lability as the predictors and CGI-S as the dependent/outcome. Adjusting for clinical diagnosis—diagnostic group was dummy coded and entered in the first step, emotional lability variables were added in the second step.

To correct for multiple comparisons, we conducted false discovery rate (FDR) correction (Benjamini–Hochberg procedure) for all the analyses mentioned above. Expected proportion of false positives was set to $\alpha = .05$. Reported results represent FDR-adjusted p-values (q-values).

2.4.1 | Supplementary material

Supplementary Material includes additional analyses. First, missing data analyses assess if EMA data for items of interest are missing at random. We also compared original findings to models that include excluded participants below the compliance threshold. Second, analyses exploring associations between positive and negative emotional lability and mood change are presented as a construct validation. Third, models were re-run using RMSSD scores of individual EMA items. Mean level data and group comparisons are presented. These analyses allow comparison between items-based models versus composite scores based models, which overall demonstrated similar patterns of the findings. Forth, to continue examining the nuances of labile mood in our sample, we calculated RMSSD scores at the daily level to supplement our original analyses at the weekly level. An additional EMA-item assessing levels of positive energy ("Since the last beep, I felt more positive or energetic than usual") was included in the EMA survey only for youth with ADHD or DMDD, due to study protocol differences. Thus, a fifth set of supplementary analyses was conducted for this item equivalent to the above analyses. Refer to the Supporting Information Material for full details and analyses.

3 | RESULTS

Question 1a. *Do diagnostic groups vary in levels of mood change?* See Table 3 for a summary of the mean level of mood change across diagnostic groups. HV youth had significantly lower levels of mood change compared with DMDD ($\beta = -.75$, SE = 0.15, $t = -5.02$, Adj. $p < .001$) and ANX ($\beta = -.34$, SE = 0.14, $t = -2.50$, Adj. $p = .046$) patients. DMDD youth had a higher mean level of mood change than ADHD ($\beta = .46$, SE = 0.17, $t = 2.67$, Adj. $p = .039$) and ANX ($\beta = .41$, SE = 0.17, $t = 2.38$, Adj. $p = .049$) patients. No other mood change differences were found.

Question 1b. *Do diagnostic groups vary in levels of positive emotional lability?* First, across the whole sample, positive emotional lability and negative emotional lability were highly correlated ($r = .61$, $p < .001$). Second, see Table 3 for a summary of the mean level of positive

TABLE 3 Mean levels of emotional lability by diagnostic group

	Diagnostic group			
Outcome measure	DMDD ($N = 31$)	ADHD ($N = 33$)	ANX ($N = 33$)	HV ($N = 33$)
Mood change mean (SD)	2.17 (1.30)	1.65 (1.04)	1.73 (0.98)	1.39 (0.71)
Positive emotional lability (RMSSD) mean (SD)	0.98 (0.46)	0.77 (0.35)	0.63 (0.29)	0.49 (0.26)
Negative emotional lability (RMSSD) mean (SD)	0.72 (0.43)	0.41 (0.26)	0.42 (0.32)	0.27 (0.26)

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ANX, anxiety disorder; DMDD, disruptive mood dysregulation disorder; HV, healthy volunteers.

emotional lability in each diagnostic group. Diagnostic groups differed in levels of positive emotional lability ($F[3, 126] = 11.37$, Adj. $p < .001$). Post hoc test showed that DMDD youth exhibited higher levels of positive emotional lability compared to the other clinical and HV groups. ADHD youth exhibited higher levels of positive emotional lability than HV youth. No other positive emotional lability differences were found.

Question 1c. *Do diagnostic groups vary in levels of negative emotional lability?* See Table 3 for a summary of the mean level of negative emotional lability in each diagnostic group. Diagnostic groups differed in levels of negative emotional lability ($F[3, 126] = 10.80$, Adj. $p < .001$). Post hoc test showed that DMDD youth exhibited higher levels of negative emotional lability compared to the other clinical and HV groups. No other negative emotional lability differences were found.

To assess if our results remained when adjusting for overall mean levels of negative and positive affect, we ran additional models including mean levels of positive and negative affect scores as covariates in these analyses. All original findings held. Specifically, groups differed with respect to negative affect fluctuations, adjusting for mean level in negative affect ($F[3, 125] = 3.52$, $p = .017$); and with respect to positive affect fluctuations, adjusting for mean level in positive affect ($F[3, 125] = 14.22$, $p < .001$). Similar to the original findings, negative affect fluctuations were higher in the DMDD group compared to all other groups. Positive affect fluctuation scores were higher among all clinical groups compared to HV, and in DMDD also compared to all other clinical groups.

Question 2. *Is global impairment associated with emotional lability symptoms?* In the whole sample, adjusting for diagnostic group, global impairment was associated with emotional lability magnitude (see Table 4). Specifically, higher levels of mood change, and negative emotional lability predicted greater impairment. Positive emotional lability did not predict greater impairment. Post hoc analyses within each of the diagnostic groups separately showed that these effects were not replicated for the separate clinical diagnostic groups; however, higher levels of mood change predicted greater impairment in the HV group. To increase power, we collapsed across DMDD and ADHD youth, as they are the groups characterized with elevated levels of emotional lability and tested the association with functional impairment within these groups. Findings showed that higher mood change was significantly associated with greater impairment ($\beta = .11$, SE = 0.05, $t = 2.14$, $p = .036$).

3.1 | Covid-19 pandemic

We ran additional sensitivity analyses for the two subgroups of participants completing EMA pre- and post- the onset of COVID-19. Groups did not differ on any demographic parameters, including age, sex, and ethnicity distributions (all $ps > .05$). Similarly, emotional lability levels were not significantly different pre- and post- pandemic for both positive emotional lability ($t = -1.11$, $df = 128$, $p = .27$) and negative emotional lability ($t = -0.61$, $df = 128$, $p = .55$). Groups did differ in terms of diagnostic distribution ($\varphi_c = 0.42$, $p < .001$), indicating that the post-COVID group included only participants with DMDD ($N = 9$) or ADHD ($N = 10$). Notably, the post-COVID subgroup included only 19 out of the full sample ($N = 130$).

TABLE 4 Associations between emotional lability and global impairment

Associations	Diagnostic group				
	Whole sample	DMDD ($N = 31$)	ADHD ($N = 33$)	ANX ($N = 33$)	HV ($N = 33$)
Mood change predicting CGI-S	$\beta = .11$	$\beta = -.20$	$\beta = .13$	$\beta = .09$	$\beta = -.14$
	SE = 0.03	SE = 0.11	SE = 0.08	SE = 0.13	SE = 0.03
	$t = 3.35$	$t = 1.81$	$t = 1.65$	$t = 0.72$	$t = -4.34$
	Adj. $p = .015$	Adj. $p = .22$	Adj. $p = .26$	Adj. $p = .64$	**Adj. $p = .005$**
Positive emotional lability predicting CGI-S	$\beta = .20$	$\beta = -.13$	$\beta = .01$	$\beta = .10$	$\beta = -.24$
	SE = 0.02	SE = 0.10	SE = 0.05	SE = 0.08	SE = 0.06
	$t = 2.27$	$t = -0.68$	$t = 0.02$	$t = 0.55$	$t = -1.24$
	Adj. $p = .09$	Adj. $p = .63$	Adj. $p = .988$	Adj. $p = .67$	Adj. $p = .42$
Negative emotional lability predicting CGI-S	$\beta = .30$	$\beta = -.16$	$\beta = .26$	$\beta = .04$	$\beta = .23$
	SE = 0.02	SE = 0.09	SE = 0.03	SE = 0.09	SE = 0.06
	$t = 3.49$	$t = -0.86$	$t = 1.46$	$t = 0.21$	$t = 1.22$
	Adj. $p = .008$	Adj. $p = .60$	Adj. $p = .33$	Adj. $p = .90$	Adj. $p = .39$

Note: Adj. p values represent significance of the associations after conducting FDR correction.

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ANX, anxiety disorder; CGI-S, clinical global impressions severity scale; DMDD, disruptive mood dysregulation disorder; FDR, false discovery rate; HV, healthy volunteers.

4 | DISCUSSION

The present study leverages EMA to investigate emotional lability in a transdiagnostic pediatric sample. This is the first study to leverage real-time assessment to dissociate positive and negative emotional lability differences across multiple diagnostic groups (Maciejewski et al., 2014, 2019; Silk et al., 2011; Tan et al., 2012). We hypothesized youth with psychopathology would have higher levels of emotional lability compared to HV participants, and this was largely supported, as all clinical groups had higher levels of mood change than HVs. Overall, DMDD youth had higher levels of mood change, positive emotional lability, and negative emotional lability than almost all other groups. ADHD youth also had higher levels of positive emotional lability than HVs. We also anticipated that DMDD and ADHD participants would have higher levels of emotional lability than ANX participants in accordance with prior literature (Dougherty et al., 2014; Sobanski et al., 2010). Interestingly, DMDD had higher levels of mood change, positive emotional lability, and negative emotional lability than both ANX and ADHD groups, but ANX and ADHD did not differ from each other. ADHD and DMDD both shared this aspect of mood lability, and these findings speak to the transdiagnostic aspect of this domain, with DMDD presenting more chronic and severe levels of this dimension. Similar and overlapping findings emerged when we tested group differences in emotional lability based on each of the emotional states individually rather than the composite scores (See Supporting Information Material).

Our findings align with previous research showing emotional lability is highly associated with ADHD, anxiety, and internalizing and externalizing symptomatology broadly (Kim-Spoon et al., 2013; Stringaris & Goodman, 2009). Current findings suggest groups may differ in daily mood change levels and advance understanding of the presentation of mood change in DMDD youth. DMDD had elevated emotional lability when compared to not only HVs but also to other clinical groups. While emotional lability has been demonstrated as a central component of ADHD in prior literature (Nigg et al., 2020; Slaughter et al., 2020), this finding was only replicated with positive emotional lability in our study. One explanation is that mood lability may be uniquely potent in DMDD youth while negative emotional lability may not be a feature of ADHD alone. It might be that EMA is parsing aspects of ADHD and mood lability that retrospective reports have been unable to achieve. Our DMDD youth also had a high comorbidity rate with ADHD (see Table 2), suggesting our findings within the DMDD sample are unique to this diagnosis, as they are not replicated in ADHD youth. These rates are of value as they reflect the typical clinical presentation of youth diagnosed with DMDD, who often have ADHD too (Freeman et al., 2016). This speaks to the ecological validity of our study and allows generalization of the findings. Overall, our findings highlight the transdiagnostic aspect of mood lability, with DMDD presenting a more severe and chronic level on this dimension.

Alongside the transdiagnostic characteristic, we found some specificity between mood change, positive, and negative emotional lability. DMDD youth endorsed more labile mood in all three categories than other groups. Positive affect fluctuations have been found to predict a later diagnosis of ADHD (Vogel et al., 2019), which aligns with our finding. However, our findings suggest that this dimension may specifically, and potentially more severely, relate to DMDD diagnosis as participants in this group demonstrated significantly higher affect fluctuations. Currently, the DSM-5 focuses on negative affect within DMDD (American Psychiatric Association, 2013). Yet this study suggests there may be a more nuanced pattern of mood dysregulation, including fluctuations in positive affect, and this should be explored further.

These findings highlight the importance of considering comorbidity when examining mood lability. The clinical diagnoses included in our analyses tend to co-occur in children and adolescents (Angold et al., 1999; Arcelus & Vostanis, 2005), as observed in the current sample (see Table 2). Hence, questions remain regarding the transdiagnostic nature of mood lability and the extent to which it is a shared risk factor or a shared outcome or symptom across different clinical presentations. Future studies conducting longitudinal designs could address the extent of mood lability as a specific versus unique factor in pediatric psychiatry.

We also hypothesized that emotional lability would be associated with functional impairment. This was supported as impairment was associated with increased emotional lability in the whole sample. This finding aligns with previous literature suggesting that negative emotional lability is highly associated with impairment across multiple domains (Beauchaine, 2015; Bunford et al., 2018; Silk et al., 2003; Stringaris & Goodman, 2009). However, our findings suggest positive emotional lability may not be as maladaptive as negative emotional lability (Karalunas et al., 2019; Rydell et al., 2003; Schoevers et al., 2021). Exploring within groups, a significant association between mood change and impairment appeared in the combined ADHD and DMDD groups and in HVs. The lack of significant associations when exploring within clinical groups may be due to power limitations. Future work should run these analyses within a larger sample and further disassociate the unique contributions of positive and negative lability to impairment.

Interestingly, some previous research indicates that positive affect may be blunted in clinical samples (Gilbert, 2012; Henry et al., 2007; Sloan & Sandt, 2010), inconsistent with the current findings. This discrepancy may be, in part, due to the specific diagnoses included in this prior work. Blunted positive lability has been found for both depression (Gilbert, 2012; Sloan & Sandt, 2010) and schizophrenia (Henry et al., 2007), diagnoses which were not included in the present study. However, current findings are in line with other research indicating that increased positive lability is associated with psychopathology and functional impairment (Rydell et al., 2003; Schoevers et al., 2021; Silverman et al., 2022). Future studies including other diagnoses, such as major depressive disorder (MDD), ODD, or conduct disorder, would allow contrasting additional clinical conditions with DMDD, ADHD, and anxiety, and would expand current knowledge of emotion lability across diagnoses.

The present study has several limitations. First, our sample was not ethnically or racially representative and was predominately

White/Caucasian (65.40%) and not Latino/Hispanic (84.60%). This lack of diversity limits the generalizability of findings and potential clinical implications that are relevant to diverse populations. We hope that future work could include a more representative and diverse sample to increase generalizability and facilitate developing more relevant assessment tools. Second, some of the EMA data was collected during the COVID-19 pandemic (March 2020 to January 2021), and although all efforts were taken to replicate procedures, the lability data that was collected may have been uniquely impacted by the pandemic. We cannot rule out the specific effects this event may have caused, but we are also unable to control for all parts of life, and our study has ecological validity. Third, medication was confounded with group, as ANX participants could not be medicated, and DMDD and ADHD participants were highly medicated. Medication may have impacted the daily experience of participants, yet there is ecological validity for testing kids that are medicated. Future studies should consider these limitations further and potentially not enroll medicated participants. A fourth limitation of the present study is related to the relatively weak correlations between the negative and positive EMA items and the modest reliability of the generated composite scores. The MCFA analyses indicated lower reliability than the conventional cutoff of 0.70 for most of the parameters tested. Notably, we found similar patterns of results and group differences as in the composite scores-based analyses when applying individual items-based analyses. From a clinical perspective, previous research suggests that combining within negative and positive emotional states may represent a more comprehensive construct of the clinical phenotype (e.g., Tuccitto et al., 2010). However, given the modest reliability in the current data, future studies replicating this analytic approach could further elucidate its value. Additionally, future studies may consider querying other specific emotional states to broaden current knowledge. A fifth limitation of the present study relates specifically to the giddiness item as it is triple-barreled. The structure of this item was partially created with the young population in mind, aiming to help our younger participants understand the meaning of this item. Future EMA studies may test more concise wording for this affective state. Finally, EMA has the advantages of collecting real-time data and across multiple time points; however, the current data includes missing data points to some extent. Notably, current compliance rates were overall high, and tests revealed data was missing at random. It is possible, however, that missing data excluded important events and specific aspects of the experience that are clinically meaningful. For example, a child might have missed answering a survey when feeling a particular emotion (e.g., extreme anger). Future studies could add passive monitoring of data, such as physiological markers, to augment data collection in vivo.

Despite these limitations, the current study provides evidence that emotional lability is a salient mechanism to understand in the context of childhood mood disorders, particularly DMDD. Our findings also highlight the importance of real-time, in vivo assessment. Targeting labile mood in vivo may be a potential treatment for DMDD, which is essential as few treatments for the disorder have been developed (Kircanski et al., 2018). In addition, this study elucidates the unique contribution of labile mood to impairment in youth. Future research should examine the associations between positive and negative emotional lability and psychopathology further, to not only elucidate unique and shared variances within labile mood, but to also inform the development of novel therapeutic interventions.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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