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Journal of Affective Disorders 351 (2024) 808–817

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Daily life affective dynamics as transdiagnostic predictors of mental health symptoms: An ecological momentary assessment study

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ARTICLE INFO

Keywords:
Affective dynamics
Ecological momentary assessment
Transdiagnostic
Mental health

ABSTRACT

Background: Affective dynamics have been identified as a correlate of a broad span of mental health issues, making them key candidate transdiagnostic factors. However, there remains a lack of knowledge about which aspects of affective dynamics – especially as they manifest in the course of daily life – relate to a general risk for mental health issues versus specific symptoms.
Methods: We leverage an ecological momentary assessment (EMA) study design with four measures per day over a two-week period to explore how negative affect levels, inertia, lability, and reactivity to provocation and stress in the course of daily life relate to mental health symptoms in young adults ($n = 256$) in the domains of anxiety, depression, psychosis-like symptoms, behaviour problems, suicidality, and substance use.
Results: Dynamic structural equation modelling (DSEM) suggested that negative affect levels in daily life were associated with depression, anxiety, indirect and proactive aggression, psychosis, anxiety, and self-injury; negative affective lability was associated with depression, physical aggression, reactive aggression, suicidal ideation, and ADHD symptoms; negative affective inertia was associated with depression, anxiety, physical aggression, and cannabis use; and emotional reactivity to provocation was related to physical aggression.
Limitations: The cross-sectional design, the limited span of mental health issues included, and the convenience nature and small size of the sample are limitations.
Conclusions: Findings suggest that a subset of mental health symptoms have shared negative affective dynamics patterns. Longitudinal research is needed to rigorously examine the directionality of the effects underlying the association between affective dynamics and mental health issues.

1. Introduction

Mental health symptoms have a strong tendency to co-occur in a manner that transcends specific diagnostic domains (Caspi et al., 2014; Murray et al., 2016). This has sparked interest in identifying variables that may serves as transdiagnostic risk or protective factors, associated with issues across the spectrum of mental health (McTeague et al., 2016; Rodriguez-Seijas et al., 2015; Snyder et al., 2019). These predictors can illuminate mental illness etiology and represent candidate targets for intervention that could potentially be leveraged to prevent or treat mental health issues in multiple domains simultaneously.

Affective dynamics can be viewed as key potential transdiagnostic constructs. The dynamic nature of emotions is essential for humans to evaluate and react to changes in their internal and external environment, particularly those relevant to their well-being (e.g., Scherer, 2009). Affective dynamics may offer valuable insights into the

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https://doi.org/10.1016/j.jad.2024.01.269
Received 28 July 2023; Received in revised form 22 January 2024; Accepted 31 January 2024
Available online 4 February 2024

psychological effects of life events and our needs and serve as markers of mental health, thus garnering substantial attention. Affective dynamics has been found to be associated with a wide range of mental health issues, including ADHD symptoms (Breaux et al., 2020; Murray et al., 2021b), internalising problems such as anxiety and depression (Brose et al., 2015; Lamers et al., 2018), behaviour problems such as aggression (Byrd et al., 2022; Slaughter et al., 2020), substance use (Buu et al., 2021; Kober, 2014), psychotic symptoms (Muddle et al., 2022), and suicidality and self-injury (Anestis et al., 2014; Victor et al., 2021).

As has been discussed by several authors, affective dynamics can manifest and be operationalised in various ways, (e.g., Kuppens and Verduyn, 2017; Trull et al., 2015). One operationalisation delineates affective dynamics aspects of emotional lability (or variability), inertia, and reactivity. Emotional lability is defined as the rapid, unpredictable, and/or intense shifts in emotions (e.g., Sobanski et al., 2010), while emotional inertia refers to the degree of persistence of emotions over time (e.g., Suls et al., 1998). Emotional reactivity pertains to how an individual emotionally responds to events (Bylsma et al., 2008). These aspects are among the most commonly assessed dynamic aspects of emotions in daily life and are associated with a wide range of mental health issues.

Indices of these aspects can be derived using ecological momentary assessment (EMA) designs, gathering data in the flow of participants daily lives, in near real-time to provide more ecological data on emotional function as it occurs in real-life contexts. In studies employing EMA or experience sampling designs, there has been a growing focus on emotional reactivity to stressors, referring to within-person changes in emotions in response to stressors (Anderson et al., 2021; Neupert et al., 2021; Speyer et al., 2023; Sun et al., 2023). This focus is important since emotional reactivity to provocations or stressors in daily life plays a central role in the theoretical link between stressful experiences and the development of mental health issues including depression, anxiety, and psychotic symptoms (Anderson et al., 2021; Booij et al., 2018; Speyer et al., 2023).

The late adolescence and emerging adulthood stages of development may have particular importance for the relations between mental health and affective dynamics given the unique challenges and experiences associated with this transitional period. During this time there is typically an increased susceptibility to mental health issues (e.g., anxiety, depression, self-injury, suicidality, and substance abuse) associated with emotion dysregulation (Ahmed et al., 2015; Lynch et al., 2021). This susceptibility may relate to various features of this developmental period, including increased emotional reactivity, reward sensitivity, and a deficiency in top-down regulatory control, possibly increasing the risk of emotion dysregulation (Murray et al., 2021c; Nelson et al., 2005; Pozzi et al., 2021; Steinberg, 2010) and the challenges associated with the developmental task of identity formation (Ben-David and Kealy, 2020; Klimstra and Denissen, 2017).

Various mental health outcomes, including depression, anxiety, substance use, suicidal ideation, self-injury, ADHD, psychosis-like symptoms, and aggression can be seen as relevant in relation to affective dynamics during this stage. Extensive research has highlighted the prevalence of depression, anxiety, substance use, suicidal ideation, and self-injury during adolescence and young adulthood (e.g., World Health Organization, 2023). Psychosis is also common in late adolescence and emerging adulthood, with a recent meta-analysis indicating a quarter of youth report psychotic symptoms (Fekih-Romdhane et al., 2022). While ADHD has traditionally been studied primarily in childhood and adolescence, there is often persistence into adulthood, with over half of diagnosed children continuing to exhibit ADHD traits in adulthood (Holzapfel, 2016). The picture is similar for aggression (a core dimension in externalising psychopathology and central to psychiatric constructs such as conduct disorder), which while also extensively studied in childhood and adolescence, shows substantial stability into adulthood (Moffitt, 1993; Vitaro et al., 2006). In fact, the transition to adulthood may introduce greater role stressors, which have also been reported to be associated with aggression (Liu and Kaplan, 2004), and aggressive behaviours in adulthood may escalate to severe forms of violent behaviours such as dating violence (Liu et al., 2013). Previous findings suggest provocation as an important trigger for reactive aggression (Bertsch et al., 2020); however, there is a lack of knowledge regarding how emotional reactivity to provocation is associated with different forms of aggression, e.g., indirect and proactive aggression. Considerable evidence also indicates that the aforementioned mental health issues have a tendency to occur concurrently (Hamza et al., 2012; Lai et al., 2015; Nitkowski and Petermann, 2011; O'Donnell et al., 2015; Rounsaville, 2007; Saylor and Amann, 2016), highlighting the potential value of transdiagnostic value of approaches that consider relations with affective dynamics and multiple mental health issue.

The associations between affective dynamics and mental health issues have mostly been supported in studies using EMA methodologies (Brown et al., 2021; Collip et al., 2013; Kranzler et al., 2018; Speyer et al., 2023). Specifically, considerable studies examined the associations between moment-to-moment (or day-to-day) negative emotional inertia (Brose et al., 2015; Koval et al., 2013; Pawluk et al., 2021), lability (Lamers et al., 2018; Murray et al., 2021b; Panaite et al., 2020), and reactivity (Anderson et al., 2021; O'Neill et al., 2004) and depression and anxiety. However, inconsistencies exist in these associations; for instance, some previous findings have suggested no association between emotional inertia and depression (see Koval et al., 2021, for a review). Very few studies have examined the association between the multiple patterns of affective dynamics and self-injurious related thoughts and behaviours (SITB) and suicidality. Findings from one study, for example, indicated that inertia, intensity, and lability of negative emotions were (weakly) related to SITB (Victor et al., 2021), and the average level of negative affect (including anxiety/agitation and shame/self-hatred) during hospitalization was related to post-discharge suicidal ideation (Bentley et al., 2021). The average level and the variability of negative affect (including shame/self-hatred) during hospitalization were linked in the same study with post-discharge suicide attempts. Additionally, some studies have examined the association between mean levels of affect or/and affective state and substance use (e.g., Bhushan et al., 2013; Phillips et al., 2014), ADHD (Gustafsson et al., 2021), psychosis-like symptoms (see Cho et al., 2017, for a review), and aggression (Rothenberg et al., 2019); however, limited studies have examined the association between different components of affective dynamics and these mental health issues using EMA approaches. Previous findings, for instance, suggested a higher average level and lower inertia of negative affect and higher negative affect inertia and liability were associated with higher cigarette dependence among dual users (e-cigarette + cigarette) and exclusive smokers, respectively (Buu et al., 2021). However, there is a dearth of research on how emotional dynamics components relate to other types of substance use, such as alcohol and cannabis use. Prior evidence has indicated that youth with ADHD experienced greater variability in positive and negative affect (including fear and distress) (Breaux et al., 2020). Concerning psychosis, a recent systematic review synthesising studies examining the relation between emotional reactivity to stress and psychotic experiences included studies utilising the experience sampling method as the main approach for assessing emotional reactivity to stress (Muddle et al., 2022). The findings of the review indicated an inconsistent, positive association between emotional reactivity to stress and psychotic experiences across both clinical and non-clinical populations. Regarding aggression, one study (Murray et al., 2021a) using the current sample did not find emotional lability to mediate the association between ADHD and any forms of aggression (including physical, indirect, proactive, and reactive aggression); however, emotional lability in the aforementioned study was calculated by mean squared successive difference (MSSD), which assesses a combination of variability and emotional inertia (Jahng et al., 2008) and is thus considered a sub-optimal method for measuring affective dynamics. Another study, also using MSSD scores to calculate emotional lability, indicated negative emotional lability was associated

with concurrent and subsequent reactive aggression, and negative emotional lability and ADHD status were related to concurrent proactive aggression in a community sample of children (Slaughter et al., 2020). This suggests that there might be distinct associations between affective dynamics and various forms of aggression. In summary, further research is needed, particularly to investigate whether other patterns of emotional dynamics beyond average levels of affect are linked with mental health issues.

Recent modelling advances for EMA data have provided new opportunities to investigating different aspects of daily life emotional functioning. Dynamic structural equation modelling (DSEM), for example, is a relatively new technique that combines multi-level, structural equation, time series and time-varying effects modelling (Asparouhov et al., 2018; McNeish and Hamaker, 2020). It achieves this by employing a multilevel model to separate observed data into within- and between-person components, applying time-series models to the within-person components, incorporating person random effects for the within-person components (which thus also contribute to the between-person component), and allowing for treating the effect of interest as a time-varying random effect (i.e., allowing for the modelling of time-varying effects) within a structural equation model (Asparouhov et al., 2018; Hamaker et al., 2021; McNeish and Hamaker, 2020). It thus provides a highly flexible framework for examining a wide range of hypotheses testable within EMA data. Using a two-level DSEM with individual random effects, for example, it is possible to model individual-level indices of components of affective dynamics to help isolate the specific aspects of affective dynamics that are associated with different mental health issues. These might include overall negative affect levels, variability in emotions (lability), emotional inertia, and emotional reactivity (Murray et al., 2022; Talty et al., 2022).

In the current study, negative affect levels are measured by the within-person mean of negative affect; emotional inertia is calculated by using the within-person autoregressive effect of an emotion (e.g., upset) from one assessment to the next (e.g., Koval et al., 2012, 2013); emotional reactivity is modelled by within-person cross-lagged paths between a stressor or provocation and an emotional reaction over time (Murray et al., 2022; Speyer et al., 2023; Sun et al., 2023). Emotional lability is captured by examining within-person variability (or residual variances) in emotions over time. Although alternative approaches, including the probability of acute change (PAC) and mean squared successive difference (MSSD) (Jahng et al., 2008), were considered in prior research, they were not selected for the current study, given they measure a combination of variability and temporal dependency (i.e., emotional inertia) (Jahng et al., 2008; Trull et al., 2015). Overall, the number of studies leveraging the advantages of DSEM in EMA data remains limited (for other studies using DSEM see e.g. Blanke et al., 2022; Gómez Penedo et al., 2021; Metcalf et al., 2021; Zhang et al., 2022).

Some important gaps remain in our understanding of the links between affective dynamics and mental health. A critical gap concerns the links between different components of affective dynamics and general versus specific mental health risk. Given the widespread association between different mental health issues and the fact that most previous EMA studies have focused on a single or a small number of mental health phenotypes, it remains unclear whether affective dynamics represent trans-diagnostic risk factors conferring risk of any or all mental health issues, or whether they are associated with specific domains of mental health. These questions can be addressed using a combination of dynamic structural equation modelling (DSEM) (Asparouhov et al., 2018; McNeish and Hamaker, 2020) to model daily life affective dynamics phenotypes and bi-factor modelling (Murray and Johnson, 2013) to separate general and specific variation in mental health symptoms. The purpose of the present study is to leverage these techniques in an EMA study with comprehensive mental health data to establish: which affective dynamics components are associated with general (shared among different symptoms) and specific (unique to particular sub-dimensions) variation in mental health during late adolescence/emerging adulthood. Nevertheless, it is important to note that the selection of mental health issues in the current study was constrained by the availability of data. Therefore, this study represents a preliminary exploration to determine whether affective dynamics can be regarded as a trans-diagnostic risk factor.

We hypothesized that levels of negative affect, negative emotional lability, and negative emotional reactivity to stress and provocation will be positively and significantly related to a) general variation in mental health symptoms and b) the specific domains of anxiety, depression, psychosis-like symptoms, substance use, aggression, ADHD symptoms, suicidal ideation, and self-injury after partialling out general risk.

2. Methods

2.1. Participants

Participants ($n = 256$, 99 males,157 females) were from the Decades-to-Minutes (D2M) study (Murray et al., 2022). D2M is an ecological momentary (EMA) sub-study of the Zurich Project on Social Development from Childhood to Adulthood (z-proso, Ribeaud et al., 2022), which was conducted following the age 20 measurement wave of z-proso. Data collection took place over a two-week period, with measurements occurring four times each day at quasi-random intervals between 10 am and 10 pm. The z-proso study, focusing on youth development (e.g., behavioural issues and mental health), began in 2004 and recruited children (with a median age of 7 years) entering elementary school in Zurich, Switzerland. With the aim of ensuring adequate representation of youth from various socio-demographic backgrounds, the z-proso study used a stratified random sampling method that accounted for school size and location. Participants (with an initial target sample of $n = 1675$) were 7 years of age at the first wave of data collection, then followed up with those at 8, 9, 10, 11, 12, 13, 15, 17, 20, and 24 years of age.

The D2M sample (median age = 20.52; age *mean* = 20.50, $SD = 0.37$) represented a convenience sample from those who took part in the age 20 wave of the z-proso cohort study. Participants were recruited from the z-proso sample, and recruitment continued until the desired sample size of 250 was reached, all of whom were informed about the EMA component and provided consent for re-contact at the start of the D2M study. The determination of this sample size was primarily constrained by the resources available for the study, making it the largest feasible size. Notably, previous power analyses for Experience Sampling Method (ESM) designs, in conjunction with Monte Carlo power analyses tailored for this study, have affirmed that the sample size ensures significant statistical power (>80 %) to detect key effects at a p-value of <0.05. This was confirmed across different analysis frameworks of interest, such as multi-level modelling, multi-level Structural Equation Modelling (SEM), and dynamic SEM (Kirtley et al., 2019; Murray et al., 2020; Schultzberg and Muthén, 2018).

Based on data availability, the characteristics of D2M participants were reported. The socioeconomic status of the D2M sample, as assessed in childhood using the International Socio-economic Index of Occupational Status (ISEI), had a mean score of 49, a value that corresponds to an occupational prestige level akin to that of a clerical worker (Ganzeboom et al., 1992). The majority of the participants ($n = 161$) had a primary caregiver born in Switzerland, while primary caregivers came from a diverse range of nations. The most common countries of origin among these caregivers included Sri Lanka ($n = 18$), Portugal ($n = 10$), Serbia and Montenegro ($n = 9$), Germany ($n = 7$), and Turkey ($n = 6$). In terms of the maximum education status of participant parents, ~26 % of parents ($n = 67$) had completed university or attended the Swiss Federal Institute of Technology, ~21 % ($n = 53$) had completed an apprenticeship in a company, ~17 % ($n = 43$) had achieved compulsory school and elementary vocational training, and ~15 % ($n = 38$) had completed A-levels. Further descriptive characteristics of the sample can be found in the study of Murray et al. (2022).

2.2. Measures

2.2.1. EMA measures

EMA measures were selected based on data availability within the D2M dataset, which focusses on stress, negative affect, aggression, and substance use in daily life.

Stress was measured using an abbreviated version of the *Perceived Stress Scale* (PSS), adapted for use in EMA studies (Murray et al., 2023b). In the D2M study, PSS included four items to assess momentary stress. These items include 'In the last 30 minutes, I felt'… (1) 'that I was unable to control the important things in my life'; (2) '…nervous and stressed'; (3) '…I could not cope with all the things I had to do'; (4) '…difficulties were piling up so high that I could not overcome them'. The items were chosen in accordance with the purpose of the PSS, which is to measure the extent to which respondents perceive their lives to be unpredictable, uncontrollable, and overloading. The items were rated on a five-point scale from *extremely* to *very slightly* (or not at all). Scores on all items were reverse coded and summed, with higher scores indicating greater perceived stress. Previous research using the current sample provided evidence of within- and between-person factorial validity (CFI = 0.993, TLI = 0.979, RMSEA =0.025, SRMR =0.011 for within level and = 0.024 for between level), internal consistency reliability (ω = 0.83 and 0.96 at the within- and between-person level, respectively), and criterion validity of the PSS (Murray et al., 2023b). In total, participants completed ~67 % of the prompts relating to perceived stress.

Provocation was assessed using an abridged version of the Aggression-ES Scale (Borah et al., 2021), the aggression-ES-A (Murray et al., 2020). In the present study, four items were selected for measuring moment-to-moment experiences of interpersonal provocation (e.g., In the last 30 min… "someone has offended me," "someone insulted me," "someone prevented me from doing something I wanted," and "someone tried to start an argument with me. I thought about a time when someone had annoyed me."). Items were rated on a four-point Likert scale (from "*very true*" to "*not at all true*"), after reverse coding, with higher scores indicating more instances of provocation while participating in the study.

Negative affect was measured using an adapted and abbreviated version of the PANAS-X negative affect schedule (Watson and Clark, 1999). The 'nervous' item of the PANAS-X negative affect schedule was removed from the D2M study because the Perceived Stress Scale (PSS) also incorporates the item '…nervous and stressed.'. Its removal was to prevent overlap, and based on feedback from pilot participants, the survey risked being overly repetitive, thus undermining participant motivation to sustain engagement with the study. The affective states of being afraid, scared, hostile, guilty, ashamed, and distressed were assessed and rated on a five-point scale from *extremely* to *very slightly* (*or not at all*). Composite scores were created by reverse coding and summing all items, with higher scores indicating more negative affect.

2.2.2. Survey measures

ADHD symptoms, *aggression* (*including physical*, *proactive*, *indirect*, *and reactive aggression*), *depression*, *anxiety*, *and psychosis-like symptoms* were measured by the Social Behaviour Questionnaire.

ADHD was assessed by 8 items, including symptoms of restlessness, being easily distracted, difficulties concentrating, doing things without thinking, being forgetful, inattention, being hectic and fidgety, and being unable to settle for long. The original version of the ADHD subscale contained 9 items; the current study removed the "restless inside" item because previous research (Speyer et al., 2023) employing the same data indicated that this item cross-loaded on the internalising problems factor (i.e., depression and anxiety subscales). In the aggression subscale, physical aggression was assessed by 3 items, including behaviours of violent attacks, hitting/biting/kicking others, and engaging in brawl; proactive aggression was measured by 4 items, including behaviours of scaring to force others, bossing others around, humiliating others, and threatening others to get something; indirect aggression was assessed by 4 items, and assessed behaviours including saying bad things behind someone's back, inciting others to dislike someone, active exclusion, and telling secrets when mad at someone; and reactive aggression was measured with 4 items, including behaviours of being aggressive when teased, insulted, and having something taken from them, and being mad when not getting something. Depression was assessed using 4 items, which assessed symptoms including being bored, unhappy, feeling alone, and being sad without reason. Anxiety was measured with 4 items, which measured symptoms including crying, fearing, being unable to doze off, and being worried. Psychosis-like symptoms were measured with 6 items, and symptoms covered hearing voices when alone, being under control of force/power, feeling persecuted, being a special/unusual person, having thoughts as if they were not my own, and seeing things other people could not see.

All items are measured on a 5-point scale ranging from *never* to *very often* and assessed behavioural/symptom frequency in the previous year, except for the internalising problems items which measure behavioural/symptom frequency over the previous month. The psychometric properties of SBQ in the z-proso sample have been evaluated and supported in previous studies (Murray et al., 2017b; Murray et al., 2019b).

Substance use was measured with a checklist of substances with the instruction: "Listed below are some drugs, intoxicants, and other substances. Have you ever taken any of them and if yes, how many times in the last 12 months?". The current analyses included alcohol (beer/wine), alcohol (spirits), tobacco, and cannabis use, and each substance was measured with one item on a six-point scale: *1 = never*, *2 = once*, *3 = 2 to 5 times*, *4 = 6 to 12 times* (*monthly*), *5 = 13 to 52 times* (*weekly*), *and 6 = 53 to 365 times* (*daily*). The aforementioned substances were included in the analysis because they are among the most commonly used substances in the z-proso sample (Steinhoff et al., 2022). Consistent with other studies in the broader z-proso sample which examined their association with mental health issues (e.g., Murray et al., 2017a; Zhu et al., 2022), the more common substances were the focus as there were insufficient instances of the use of rarer substances within the D2M sample to permit robust analyses involving them.

Suicidal ideation and *self-injury* were both assessed by one item each that asked participants how often they had thoughts about suicide/intentionally self-injured during the past month, using a five-point scale (1 = *never* to 5 = *very often*). Such one-item measures are commonly used to assess youth suicidal ideation and self-injury (e.g., Donath et al., 2019) and can serve as a brief and valid approach for screening.

2.3. Data collection

The main D2M data was collected during the winter of 2018, approximately three months after the age 20 main z-proso data collection. Participants downloaded an application provided by LifeDataCorp LLC that enabled the administration of measures on their smartphones. At each point of measurement, participants received a notification directing them to a brief survey. Incentives were based on the level of compliance, with participants receiving up to 50 Swiss Francs (CHF; 1 CHF is approximately worth 1 USD) if they achieved a response rate of at least 70 % in both weeks one and two of the study. The study was carried out by the Decision Science Laboratory (DeSciL) at ETH Zurich.

Drawing from the study of Murray et al. (2023c), which examined compliance rates and their predictors for the D2M sample, the mean number of prompts completed was 33.53 (*SD* = 15.87, range = 1–56; median = 39). Notably, youth displaying higher levels of aggression and tobacco use exhibited lower compliance rates, whereas those with higher levels of self-injury had higher compliance rates. On the other hand, none of migration background, socioeconomic status (SES), gender, ADHD symptoms, depression, anxiety, psychotic-like symptoms, stress, alcohol use, or cannabis use, showed significant associations with EMA compliance.

2.4. Ethical considerations

Ethical approval for these studies was obtained from the University of Zurich's.

Faculty of Arts and Social Science's Ethics Committee. Before data collection, written informed consent was obtained from participants.

2.5. Statistical procedure

2.5.1. Overview

Models were built in two main stages in which we first separately established measurement models for the mental health and affective dynamics using CFA and DSEM respectively and then combined them into a single model. All analyses were performed using Mplus 8.8 version. These steps are described in turn below. Analyses were pre-registered at: https://osf.io/7u24b.

2.5.2. Mental health measurement model

Our first goal was to explore the relations between affective dynamics and each dimension of mental health individually, and for this, used unidimensional models for each of our mental health phenotypes. We used confirmatory factor analysis to check that the fit of each measurement model was adequate.

Our second goal was to explore the relations between affective dynamics and dimensions of mental health, by separating out general and dimension-specific variance. For this, we developed a bi-factor measurement model for the mental health dimensions in which all items loaded on a general mental health factor and subsets of variables loaded on the specific dimensions of ADHD symptoms, aggression, depression, anxiety, psychosis-like symptoms, substance use, suicidal ideation, and self-injury. Scaling and identification were achieved by fixing the latent variable variances to 1. In addition, to impose a separation between general and domain-specific mental health variation, we fixed the inter-correlations between all latent factors to 0. If models did not fit well, we examined modification indices and expected parameter changes to inform model modifications.

For both sets of models we used Bayesian estimation for consistency with the DSEM analyses (described below). Convergence was based on a potential scale reduction (PSR) value of <1.1 and was checked after a minimum of 2000 iterations. Default diffuse priors were used. To evaluate model fit, we used the criteria of the 90 % credible interval for RMSEA excluding values above 0.06 and the 90 % credible intervals for TLI and CFI excluding values below 0.95 to define good fit (Asparouhov and Muthén, 2021). Prior to this, we checked the RMSEA for the baseline model to ensure it was not <0.15, indicating that approximate fit indices should not be used (Asparouhov and Muthén, 2021).

2.5.3. Affective dynamics model using a two-level DSEM

Affective dynamics were modelled using a dynamic structural equation model (DSEM). DSEM is a modelling technique that combines multi-level modelling, structural equation modelling, time-varying effects modelling, and time-series modelling (Asparouhov et al., 2018). In the present study we used a two-level DSEM in which we included random effects for individuals but not time. Given the proneness of DSEM to convergence issues, we built the model in steps, adding variables and random effects gradually in order to identify any cases or model components that could result in slow convergence. For example, cases with a lack of temporal variation and random effects with very small variances can often be removed to improve convergence without substantively affecting the model (Asparouhov and Muthén, 2022).

To operationalise our hypotheses, we first fit a model including the negative affect and stress data. In this model, at the within-person level, we modelled an intercept, autoregressive slope (i.e., stress and negative affect predict themselves over time), and cross-lagged slopes (i.e., stress and negative affect predict each other over time) for the lag-1 links between negative affect and stress. We also included residual variances for negative affect and stress. Person-level random effects were included for all of these parameters. At the between-person level, the associations between these intercepts, autoregressive effects, cross-lagged effects (i.e., from stress to negative affect), and residual variances (representing levels, inertia, reactivity, and lability respectively) and each mental health domain were evaluated.

In addition to emotional reactivity to stressors, emotional reactivity to provocation was also investigated in the current study, since provocation is a commonly experienced emotionally evocative stimulus that may particularly relate to aggressive behaviour (Finkel and Hall, 2018; Stadler et al., 2006). We, therefore, also fit analogous models combining negative affect and provocation data and examined the relations between affective dynamics operationalised in terms of provocation and affect and each mental health symptom domain. Exploring these alternative operationalizations of daily life emotion dynamics allowed us to compare findings and establish which mental health symptoms relations replicated across the different models.

3. Results

3.1. Measurement model

The model fits for the unidimensional CFAs and item loadings are provided in Table S1 of the supplementary materials. Model fit statistics for physical, indirect, and reactive aggression, depression, and anxiety indicated good results. The model fit for proactive aggression fell below conventional criteria for good fit but was judged acceptable for the purposes of the present study. In contrast, model fits for ADHD symptoms, substance use, and psychosis-like symptoms fell below conventionally acceptable levels. We thus added correlated error terms indicated by modification indices and re-evaluated model fit for these three models, and model fits were acceptable (see Table S1 for details).

Following this, a bi-factor confirmatory factor analysis model was fit to these data, with a general factor loading on all items and specific (group factors) loading on subsets of items. In addition to the mental health dimensions mentioned above, single items assessing the self-injury and suicidal ideation domains were added to the bi-factor model. Model fit and item loadings generally indicated that this model did not fit the data well (see Table S2 of the supplementary materials). Thus, for subsequent analyses we focused on the individual domain-specific CFAs. We used these unidimensional CFAs within two-level dynamic structural equation models (DSEM) in order to evaluate the association of levels of negative affect, negative emotional lability and inertia, and negative emotional reactivity to stress and provocation with specific symptoms.

Given the aforementioned, existing literature provides preliminary evidence that emotional dynamics components may be variably linked with different forms of aggression. Moreover, the aggression measure used in the current study explicitly outlines sub-dimensions of aggression, which provides a structured framework enabling us to explore how affective dynamics are associated with specific types of aggressive behaviour. For substance use, in addition to examining it together (all four substances loaded on a latent factor representing overall substance use), as a supplementary analysis, we separately investigate each substance separately, given these substances may link with emotional dynamics components in different ways and Switzerland has different regulations and attitudes towards alcohol, tobacco, and cannabis use (e.g., Switzerland has lenient regulations on alcohol, legal and regulated tobacco use, and decriminalised personal possession of cannabis; however, the sale and cultivation of cannabis remains illegal in the country).

3.2. Two-level dynamic structural equation models

To achieve convergence, it was necessary to remove the within-person level parameter representing the effect of emotion on provocation (emotion→provocation) from all models related to provocation-

emotion-mental health outcomes; and the within-person level parameter of the effect of emotion on stress (emotion→stress) from specific stress-emotion-mental health outcomes models, which included substance use, psychosis, and indirect aggression models. As did not have specific hypotheses about this parameter (emotion→provocation/stress), this was not considered to be a major issue for the interpretation of our findings. Additionally, cases with no temporal variation in emotion and/or stress/provocation were also removed from certain models to ensure convergence. The results of DSEM (with standardised estimates reported) are provided in Tables S3 and S4 of supplementary materials.

Results for the models including momentary stress and negative affect indicated that, at the within-person level, the autoregressive and cross-lagged effects between negative effects and stress in all symptoms models were all significant.

At the between-person level, higher mean levels of negative affect were associated with greater indirect and proactive aggression, and psychosis-like symptoms ($\beta_{indirect}$ = 0.312, 95%CI: 0.058–0.530; $\beta_{proactive}$ = 0.373, 95%CI: 0.020–0.690; $\beta_{psychosis}$ = 0.615, 95%CI: 0.331–0.773). Higher mean levels of stress ($\beta_{depression}$ = 0.298, 95%CI: 0.088–0.489; $\beta_{anxiety}$ = 0.228, 95%CI: 0.017–0.420; $\beta_{suicidal}$ = 0.241, 95%CI: 0.073–0.392) were associated with higher depression, anxiety, and suicidal ideation.

Higher stress inertia was associated with higher levels of depression ($\beta_{depression}$ = 0.350, 95%CI: 0.108–0.545). Further, stronger negative emotional lability ($\beta_{depression}$ = 0.193, 95%CI: 0.007–0.377; $\beta_{reactive}$ = 0.351 95%CI: 0.097–0.560; $\beta_{suicidal}$ = 0.246, 95%CI: 0.064–0.405; β_{ADHD} = 0.304, 95%CI: 0.140–0.460) was related to higher depression, reactive aggression, suicidal ideation, and ADHD symptoms. However, there were no significant relations between both emotional inertia and emotional reactivity defined by stress➔affect relations and the mental health outcomes.

Results for the models including momentary provocation and negative affect suggested that, at the within-person level, the autoregressive and cross-lagged effects between provocation and negative affect were significant across symptoms models.

At the between level, higher mean levels of negative affect ($\beta_{depression}$ = 0.654, 95%CI: 0.444–0.776; $\beta_{anxiety}$ = 0.456, 95%CI: 0.180–0.655; β_{injury} = 0.417, 95%CI: 0.172–0.600; $\beta_{psychosis}$ = 0.530, 95%CI: 0.160–0.732) were associated with higher depression, anxiety, self-injury, and psychosis-like symptoms, while were negatively associated with physical aggression ($\beta_{physical}$ = −0.870, 95%CI: −0.909- −0.823). Further, higher mean levels of provocation ($\beta_{physical}$ = 0.332, 95%CI: 0.262–0.412; $\beta_{proactive}$ = 0.326, 95%CI: 0.058–0.531; $\beta_{indirect}$ = 0.283, 95%CI: 0.072–0.464; $\beta_{reactive}$ = 0.289, 95%CI: 0.071–0.456) were associated with greater physical, proactive, indirect, and reactive aggression.

Stronger negative emotional lability ($\beta_{physical}$ = 0.288, 95%CI: 0.230–0.353; $\beta_{reactive}$ = 0.427, 95%CI: 0.188–0.592; β_{ADHD} = 0.251, 95%CI: 0.062–0.423) was related to more physical, reactive aggression, and ADHD symptoms. Higher negative emotional inertia ($\beta_{depression}$ = 0.176, 95%CI: 0.008–0.335; $\beta_{anxiety}$ = 0.231, 95%CI: 0.046–0.410; $\beta_{cannabis}$ = 0.179, 95%CI: 0.011–0.337; $\beta_{physical}$ = 0.153, 95%CI: 0.094–0.215) was related to higher levels of depression, anxiety, cannabis use, and physical aggression. Stronger emotional reactivity to provocation was associated with higher physical aggression ($\beta_{physical}$ = 0.077, 95%CI: 0.015–0.139), but were negatively related to self-injury (β_{injury} = −0.219, 95%CI: −0.402- −0.019).

4. Discussion

Affective dynamics have been proposed as candidate transdiagnostic processes in a wide range of mental health issues. However, they can manifest in a number of ways, and it is unclear which aspects are transdiagnostic versus dimension-specific in their relations to mental health, especially as regards affective dynamics processes as they play out in the course of daily life. The current study thus used EMA to assess affective dynamics in ecological context (daily negative emotion level, emotional over-reactivity, lability, and inertia) and examined their association with mental health issues (ADHD symptoms, aggression, depression, anxiety, psychosis-like symptoms, substance use, suicidal ideation, and self-injury) in late adolescence/early adulthood. DSEM was used to model and examine individual differences in these affective dynamics processes based on the mental health phenotypes. We found that higher negative affect levels were associated with greater depression, indirect and proactive aggression, psychosis, anxiety, and self-injury symptoms; stronger lability with higher depression, reactive aggression, suicidal ideation, ADHD, and physical aggression symptoms; and greater inertia with higher depression, anxiety, cannabis use, and physical aggression in at least one model (stress versus provocations as the stressor); and greater emotional reactivity to provocation with higher physical aggression. Findings that were consistent across both models were the links between psychosis and negative affect levels, and between reactive aggression and ADHD, and emotional lability.

In the current study, a bi-factor model was not supported for the set of mental health phenotypes examined. This is in contrast to previous research that has supported widespread co-occurrence between different mental health issues and correspondingly supported a bifactor model to capture this (Caspi et al., 2014; Laceulle et al., 2015; Tackett et al., 2013). However, there are also a growing number of studies that have expressed scepticism about the extent of this generalised variance in mental health symptoms and whether it is well-captured in a bi-factor model (e.g., Murray et al., 2019a). Indeed, in our model we found that the general factor was not truly general but dominated by symptoms from two mental health domains (i.e., depression and anxiety). Given this, we elected to examine the relations between the affective dynamic components and mental health phenotypes individually rather than use the planned approach of a bifactor model discussed in our pre-registration. Consistent with the lack of support for a bi-factor model, all emotional dynamics components were significantly associated with only a subset of mental health outcomes.

The current finding nevertheless identified some mental health issues characterised by shared or similar patterns of emotion dynamics. Specifically, findings suggested negative emotional liability was related to various mental health issues, including depression, suicidal ideation, ADHD, and aggression (including physical and reactive aggression). Emotional lability, reflecting a fluctuating emotional state with relatively large moment-to-moment shifts, may be indicative of a lack of effective emotion regulation skills to stabilise emotions. This aligns with the fact that emotion dysregulation is a common feature in some psychopathological conditions, such as depression, anxiety disorders, ADHD, and externalising disorders (American Psychiatric Association, 2013). Furthermore, our findings imply that emotional lability could act as a marker for suicidality, which holds important implications for suicide research, as most existing studies have focused on the role of mean levels of negative and/or positive affect in suicidality. However, further research is needed to determine whether daily life negative emotional lability serves as an early warning sign or vulnerability to internalising and externalising symptoms, or whether it represents manifestations of these symptoms.

Some evidence has also pointed to negative emotional lability as a potential mechanism linking different domains of mental health together. For example, previous research has suggested that emotional lability associated with ADHD symptoms may serve to increase the risk of the development of additional mental health issues (Murray et al., 2021b; Slaughter et al., 2020). Other studies have pointed to its potential role in the co-occurrence of externalising and internalising problems (Leaberry et al., 2017; Stringaris and Goodman, 2009). Future studies using a measurement burst design to capture affective dynamics processes and mental health symptoms repeatedly over time will be required to clarify their roles (as a marker, outcome, or underlying cause or linking mechanism between specific mental health issues).

Additionally, the findings indicated that negative emotional inertia

was linked with depression, anxiety, physical aggression, and cannabis use. This finding, coupled with the identified link between higher levels of negative emotions and increased symptoms of depression and anxiety, may imply that these patterns of negative emotional dynamics in internalising symptoms are characterised by an emotional life reaching more extreme levels, along with a prolonged self-predictive effect that slows down the recovery process or returns to normative emotional states. Further, researchers have proposed that emotional inertia is more likely a marker of heightened vulnerability to future depressive episodes than a consistent feature in currently depressed individuals, with evidence from increased inertia in those with sub-clinical depressive symptoms, especially among younger populations, implying its potential role as an 'early warning signal' for transitions between healthy and depressed states (see Koval et al., 2021, for a detailed discussion). Further research that integrates longitudinal and EMA designs is essential to investigating this proposal. Regarding cannabis use and physical aggression, this could potentially be explained by individuals with stronger negative emotion inertia resorting to cannabis consumption or engaging in aggressive behaviour as a strategy to regulate or express their persistent negative emotions. Additionally, physical aggression showed an association with increased reactivity to provocation with negative emotions, in combination with the finding of its relation to emotional lability. This may imply the presence of various dysfunctional emotional processes in physical aggression, characterised by emotionally over-reactive response to provocation events, rapid emotional shifts, coupled with a lack of effective homeostatic tendencies to return to normative emotional states. Further research is necessary to explore the associations of emotional dynamic components with various types of externalising symptoms (including directions and mechanisms underlying this association).

One counterintuitive finding involving the negative association between emotional reactivity to provocation and self-injury is difficult to explain using existing theories, and more research is required to examine this association. In terms of psychosis, self-injury, and indirect and proactive aggression symptoms, these symptom domains were linked to higher levels of negative emotion, after adjusting for a for other forms of affective dynamics. Nevertheless, further research, as mentioned earlier, is necessary to ascertain whether these dysfunctional affective processes serve as markers, outcomes, or linking mechanisms of these mental health issues.

These findings may suggest that interventions that target a range of affective dynamics processes could be beneficial in addressing a broad spectrum of mental health issues. Nevertheless, it is important to note that the current analysis of mental health issues utilises a convenience rather than a comprehensive set of mental health measures, and the current findings are cross-sectional in nature. Longitudinal research with comprehensive mental health measures is needed to examine the temporal influence between affective dynamics and mental health symptoms.

4.1. Limitations

Limitations of the present study should be noted. First, the associations between affective dynamics processes and mental health issues found in the current study were cross-sectional in nature, which should be interpreted with caution. In particular, we used the affective dynamics processes assessed in the D2M data collection to predict mental health symptoms collected in the age 20 main z-proso survey that was collected approximately three months earlier than the D2M data collection, as mentioned previously. The results need to be interpreted with caution due to the temporal order of the variables collected. However, the time interval between these two surveys is quite short, and the current findings provide preliminary evidence on the association between multiple affective dynamics components and mental health problems. Second, this study may be limited by its small sample size, whereas larger sample size examinations will be important in future replications. Third, the current findings might be limited by the EMA survey with a small number of questions and a lack of detail; however, this brief-survey design was necessary for the EMA study (Wrzus and Neubauer, 2023), in which the D2M participants needed to complete a survey four times a day for two weeks. Extended questionnaires may have imposed an undue burden on participants, potentially resulting in an increased attrition rate. Fourth, the D2M sub-sample was a convenience sample drawn from the age 20 wave of the z-proso study, potentially introducing selection bias. Despite the relative diversity in the birthplaces of primary caregivers in the current sample, the demographic makeup of the current sample and the lack of a large, representative sample raises concerns about potential biases. This could impact the overall generalisability of the study's findings. Moreover, the current study focused on the age groups of late adolescence and emerging adulthood. Due to the unique challenges and developmental-related vulnerabilities in these specific age groups, caution is needed when applying the results to different age groups or populations. Fifth, the study's findings might be affected by missing data in affective dynamics measures, posing a potential source of bias that could compromise the accuracy and completeness of the assessment of affective processes (Murray et al., 2023a). Nevertheless, it is noteworthy that, in the current study, the complete rate is acceptable (on average, participants completed approximately 60 % of the prompts) in terms of studies using EMA design. Finally, due to data availability limitations, only a subset of mental health issues has been included in the current analysis; for example, the dataset used in the current study did not include a measure of eating disorders, and certain measures, such as anxiety symptoms, were not assessed in a detailed manner.

4.2. Future directions

There are several future directions from the current study merit discussion. First, future studies would benefit from including both positive and negative emotions, given that positive emotional lability may also be associated with mental health or neurodevelopmental symptoms (Breaux et al., 2020). Second, future research should collect developmental EMA data (i.e., the combination of longitudinal and EMA designs) that can be used to illuminate how affective dynamics develops over time and may be related to the risk of developing mental health issues. Third, in future work, it will be worthwhile to investigate the mechanisms underlying the association between affective dynamics processes and mental health symptoms, e.g., to answer question such as whether individuals with high emotional inertia show this association pattern because of ruminative tendencies. Finally, future research should collect higher temporal resolution data to map how emotions change over time in a more fine-grained fashion. For example, with higher resolution data it may be possible to operationalise individual differences in the onset and decay of a negative affective reaction to naturalistic events and examine how those curves relate to different domains of mental health.

5. Conclusions

No affective dynamics component was found to be associated with all of the mental health symptoms examined in this study. Nonetheless, the findings indicate that emotional lability was positively associated with a subset of mental health issues in late adolescence/emerging adulthood, including aggression (including physical and reactive), depression, ADHD symptoms, and suicidal ideation; that higher negative affect levels were related to depression, indirect and proactive aggression, psychosis, anxiety, and self-injury; that stronger negative emotional inertia was linked with depression, anxiety, physical aggression, and cannabis use; and that emotional reactivity to provocation was positively related to physical aggression. Taken together, these findings imply that dysfunctional affective processes may be makers for these symptoms; however, more research is needed to clarify the nature and

direction underlying these associations.

Funding

Funding from the Swiss National Science Foundation (Grants 405240-69025, 100013_116829, 100014_132124, 100014_149979, 100014_149979, 10FI14_170409/1, 10FI14_170409/2, 10FI14_198052/1), the Jacobs Foundation (Grants 2010-888, 2013-1081-1), the Jacobs Center for Productive Youth Development, the Swiss Federal Office of Public Health (Grants 2.001391, 8.000665), the Canton of Zurich's Department of Education, the Swiss Federal Commission on Migration (Grants 03-901 (IMES), E-05-1076), the Julius Baer Foundation, and the Visana Foundation is gratefully acknowledged.

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Declaration of competing interest

None.

Acknowledgements

We are grateful to the research assistants and participants of the z-proso study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2024.01.269.

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