How was your child's temperament today and last week?

Considering within-person variability in the measurement of infant temperament

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Abstract

Infant temperament is usually considered biologically driven and a precursor of personality. Despite being conceived as trait measures, parent reports for assessing infant temperament use short timescales, for example, the past 7 days, implying variability in temperament traits' expressions. In two daily diary studies, we use the perspective of whole-trait theory to investigate whether infant temperament is observable on a daily basis and to what degree infant temperament varies within-person across days. In Study 1, $N = 137$ mothers of infants aged 6-18 months reported on their infant's daily (state) temperament (median number of days: 8, total observations: 984). The results suggest a substantial within-person variation in daily infant temperament (ICCs: .41 to .54). Study 2 ($N = 199$ mothers, median number of days: 7, total observations: 1375) replicated these results on the variability in infant state temperament (ICCs: .41 to .51). In addition, infant state temperament was related to infant trait temperament. However, certain temperament items – primarily those assessing surgency – were frequently rated as not applicable and did not seem suitable for daily assessments. Across both studies, results indicate substantial within-person variability in daily infant temperament and a strong trait component.

Keywords: infant temperament, within-person variability, whole trait theory, daily diary

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"No trait theory can be sound unless it allows for, and accounts for, the variability of a person's conduct". (Allport, 1961; p.333)

Infant and child temperament are consensually considered precursors of personality and have been shown to predict adult personality (Shiner, 2019; Tang et al., 2020) and life outcomes 30 years later (Wright & Jackson, 2022). Because infant temperament is typically conceptualized as a biologically driven trait, high stability is assumed or implied. However, with increased interest in describing infant development on different timescales (e.g., by linking daily behavioral variation to long-term developmental change), it is important to investigate how infant temperament manifests itself and whether it can be measured on shorter timescales, such as days.

Whole Trait Theory

In studying how parent-reported infant temperament varies from day to day, we draw on theoretical conceptions from personality psychology, in particular on whole trait theory (Fleeson & Jayawickreme, 2015, 2021). Whole trait theory suggests that personality traits can be understood as a density distribution of personality states, that is, momentary enactments of personality traits (Fleeson, 2001). From this perspective, individuals can be described not only in terms of the mean of the density distribution but also in terms of the variation of the observed personality states. In terms of assessment, individuals are assessed multiple times (typically within similar and/or different situations), allowing a description of both the consistency and dynamics of personality states. For instance, 13-month-old Joshua might be described by an average mean level of negative affectivity and a low variation in displaying negative affectivity. That is, Joshua displays some negative emotionality across many situations and times but does not vary a lot in his reactions to different situations or across

different days. Another 13-month-old, Nora, might also be described by an average mean level of negative affectivity but high variability in displaying negative affectivity. Nora could be characterized by showing strong negative emotional reactions in certain situations (such as being restricted) on certain days but not showing any negative emotional reactions in other situations or on other days.

Infants, as well as people in general, typically show a wide range of different behaviors, which may appear to contradict the notion of a relatively stable temperament or personality. Whole trait theory proposes a way to reconcile this seeming inconsistency. It suggests that traits can both be relatively stable and vary in their expression across situations. Findings in adults regarding different personality traits have suggested substantial variability in personality states at the within-person level (i.e., the personality states of one person typically vary substantially across different situations or days). At the same time, studies have also supported substantial between-person variability in the density distribution of personality states (that is, general differences in the overall level of personality dimensions between persons), allowing to identify consistency (Fleeson & Jayawickreme, 2021). In adult personality, trait measures of personality are strong predictors of state manifestations, despite variability in state manifestations of personality (Fleeson & Gallagher, 2009). To our knowledge, these ideas have, however, never been applied to the study and assessment of (infant or child) temperament. In the present study, we thus investigated whether this general pattern of substantial within-person and between-person variability also holds for the dimensions of infant temperament. We also explored the implications of this perspective for the assessment of infant temperament.

Dimensions of Infant Temperament

Temperament is most typically conceptualized to describe individual differences in reactions to internal and external stimuli and in self-regulatory processes. An individual's

temperament is expressed in a general pattern of responses shown in behavior (Rothbart & Bates, 2006). In other words, temperament traits can be defined as "early emerging basic dispositions in the domains of activity, affectivity, attention, and self-regulation" (Shiner et al., 2012, p. 437). However, "temperament is not a static construct but one that develops" (Stifter & Dollar, 2016, p. 547) in interaction with genetic predispositions and the environment. For instance, infants who cry more often or are more easily excited evoke different parental soothing strategies (Stifter & Moding, 2018), shaping the development of temperament (Stifter & Dollar, 2016). Thus, behavioral manifestations of temperament differ by age and change over time.

In infancy, temperament typically manifests in the child being easily startled, excited, or soothed. While the concrete dimensions of infant temperament described by different theoretical conceptions differ, they may be summarized under the dimensions of emotionality, extraversion, activity, and persistence (Mervielde & Asendorpf, 2000). In the present study, we investigate the higher-order dimensions of surgency, negative affectivity, and orienting/regulation as conceptualized by Mary Rothbart (Gartstein & Rothbart, 2003).

In this research tradition, infant temperament is usually treated as a biologically driven trait that is assumed to be innate to some extent (see Bridgett et al., 2015, for a review on self-regulation). Infant and child temperament are usually considered precursors of personality and have been shown to predict adult personality decades later (Shiner, 2019; Tang et al., 2020). In terms of the five-factor model of personality (McCrae & John, 1992), surgency is seen as a precursor of extraversion, negative affectivity as a precursor of neuroticism, and orienting/regulation as a precursor of conscientiousness.

Assessment, Stability, and Variability of Infant Temperament

Parent questionnaires represent the most common method for assessing infant temperament (Kiel et al., 2018), despite being subject to biases and limitations (e.g., Gartstein

et al., 2012). Parents are seen as being in a unique position to observe their infants across many different situations and over longer time periods compared to other observational measures (Rothbart & Bates, 2006). The temporal stability of temperament measures is usually higher for parental reports than for observational measures (Stifter & Dollar, 2016). Already during infancy, parent ratings of infant temperament are relatively consistent across situations (Wachs et al., 2004) and time (Bornstein et al., 2015; Casalin et al., 2012, Gartstein et al., 2015; Putnam et al., 2008; Sieber & Zmyj, 2022). Generally, studies supported the notion that the stability of temperament increases with age (Lemery et al., 1999) and decreases with the length of the interval between assessments (Bornstein et al., 2015). Although there might be differences in the stability of different temperament dimensions (e.g., Lemery et al., 1999; Worobey & Blajda, 1989), the overall pattern remains unclear.

Despite being conceived as trait measures, parent reports of infant temperament commonly use relatively short timescales as a reference in their instructions, such as the past seven days in the Infant Behavior Questionnaire (IBQ; Gartstein & Rothbart, 2003; Putnam et al., 2014). This implies that all described behaviors should be observable on a daily basis. Yet, to date, no study has asked parents to report daily on their infants' temperament to determine if all behaviors are observable daily. Therefore, it remains unknown if infant temperament is observable daily and if it varies within individuals across multiple days.

Most studies on the stability of infant temperament focused on intervals of several months, and the shortest time intervals used have typically been six weeks or three months (Bornstein et al., 2015; Carranza Carnicero et al., 2000; Sieber & Zmyj, 2022; Worobey & Blajda, 1989). However, given the growing interest in describing infant development on different timescales, for instance dynamics in parental soothing and infant regulation (Buhler-Wassmann & Hibel, 2021), it becomes pertinent to investigate how infant temperament manifests itself on shorter timescales, such as days. Studies in adults and school-aged

children have particularly focused on within-person variability with regard to negative affect (e.g., Brose et al., 2019; Könen et al., 2016) and higher variability in personality states has been typically associated with higher trait neuroticism/emotional instability (Eid & Diener, 1999). We, consequently, expect negative affectivity (as a trait) to be associated with increased variability in daily temperament states.

Overview and Aims of the Present Studies

In two studies, we investigated the variability of infant temperament by assessing daily fluctuations in parent-reported temperament across 10 days. In Study 1, we investigated two higher-order dimensions of infant temperament (negative affectivity and orienting/regulation) using a daily diary design. In Study 2, we replicated Study 1's findings and extended them by assessing a third dimension (surgency) and collecting assessments on trait infant temperament at baseline. Overall, both studies addressed the following research questions:

- Do daily measures of infant temperament show substantial within-person and between-person variance? (Studies 1 and 2)
- Does within-person variance of daily infant temperament differ between different dimensions of infant temperament? (Studies 1 and 2)
- Are temperament states substantially related to the respective temperament trait? (Study 2)
- Is within-person variance in daily (state) temperament (across all temperament dimensions) related to the trait temperament dimension of negative affectivity? (Study 2)

In addition, in Study 2 we investigated the characteristics of individual temperament items (mean, within-person variation, between-person variation) when assessed daily. We also studied the associations of the aggregated state item with its corresponding trait item and

scale. Study 1 is exploratory and has not been preregistered, Study 2 is confirmatory and has been preregistered (https://osf.io/fb74t/?view_only=27907f4fcb94427ba1bf1fcb5a6a9a46).

Study 1: Variability of Infant Temperament

In Study 1, we investigated exploratively to which extent daily assessments of parent-rated infant temperament show between- and within-person variability. The study was part of a larger data collection during the COVID-19 pandemic (Reinelt et al., 2022). Because previous studies using German versions of the IBQ and its short forms (Gartstein & Rothbart, 2003; Putnam et al., 2014) had only found two factors (Bayer et al., 2015; Sieber & Zmyj, 2022, Vonderlin et al., 2012), we only assessed the dimensions of negative affectivity and orienting/regulation (and not surgency) in Study 1. This study's data can be freely obtained from Zenodo: https://zenodo.org/record/6399959#.ZAVAaa2ZND8.

Method

Participants. *N* = 357 parents participated in the larger study (Reinelt et al., 2022). In the present study, we included only mothers (i.e., participants who identified as female) with infants aged 6 to 18 months who completed the baseline questionnaire (containing the demographic questions) and at least two of the ten daily diaries. We further excluded data from very preterm-born children (i.e., < 32 weeks of gestation at birth) and diary data from days without variance on an item level (i.e., same answers for all nine temperament items).

This resulted in a final sample of *N* = 137 infants. Infants were *M* = 11.6 months old (*SD* = 3.21 months), 45.3% were boys, and 54.7% were girls. Mothers were *M* = 34.9 years old (*SD* = 4.01 years, range: 24–49 years). Most of the mothers (*n* = 127, 94.1 %) lived in Switzerland, and 54.8% had a migration background (i.e., were born outside of the country of residence). At the time of the survey, 68.9% of the mothers were working either full-time or part-time, whereas 31.1% were on maternity leave or unemployed. Overall, participating mothers were highly educated (82.2% reported having a tertiary education degree) and

reported a median household income of 10’000 - 12’000 CHF (inter-quartile range: [7’500 - 8’700 CHF; 12’000 - 15’000 CHF])[1], which is above the average Swiss household income of families with children younger than four years of age (approximately 8’300 CHF, Bundesamt für Statistik, 2021).

Procedure. Participants were recruited from April to July 2021. To recruit participants, we mainly contacted parents who had given birth in the 18 months prior to the study at the REDACTED FOR BLIND REVIEW and who had provided general consent to be contacted for research studies. Additionally, the study was promoted on social media, targeting parents from German-speaking countries. After giving informed consent, participants completed a baseline online questionnaire. Starting the following evening, they were invited by e-mail to complete a diary survey every evening for 10 consecutive days. On average, mothers reported on their infant’s temperament on 7.14 days (*SD* = 2.85 days; median: 8 days, $N_{\text{total observations}}$ = 984).

Measures. Daily infant temperament was assessed by an adaptation of the German version of the IBQ (Gartstein & Rothbart, 2003; Putnam et al., 2014) used in the German National Educational Panel Study (NEPS; Bayer et al., 2015). This version assesses two higher-order temperament dimensions, negative affectivity (4 items) and orienting/regulation (5 items). The items are answered on a 7-point Likert-type scale (ranging from 1 = “never” to 7 = “always”). To make the instrument suitable for assessing daily temperament, the instructions and all items were rephrased to refer to the current day. For instance, an item starting with “If your child was tired,…”, was adapted to “If your child was tired today,...”. In most cases, this only required a slight adaptation of the item. Mothers could also indicate that an item did not apply on the respective day. The study (both baseline and daily diary) contained several other measures, as described in Reinelt et al. (2022).

Results

Composition of Within- and Between-Person Variances of Daily Infant Temperament. Intra-class correlations (ICC) were computed to differentiate between-person variability from within-person variability and measurement error in mothers' daily assessments of infant temperament. The ICC and 95% bootstrap confidence interval (CI) for negative affectivity was ICC = .54, 95%-CI: [.46; .62], indicating that 54% of the daily variance of the negative affectivity dimension could be attributed to between-person differences, that is, differences between mothers. Likewise, an ICC = .41, 95%-CI: [.32; .49], for orienting/regulation indicated that 41% of the daily variance of the orienting/regulation dimension could be attributed to between-person differences.

MacDonalds ω was calculated to assess whether the temperament dimensions could be reliably assessed both on the between-person and the within-person level. Results indicated high reliabilities on the between-person level (negative affectivity: ω = .86; orienting/regulation: ω = .89) and satisfactory reliabilities on the within-person level (negative affectivity: ω = .60; orienting/regulation: ω = .66).

Differences in Variability Across Temperament Dimensions. When comparing the within-person means and standard deviations between the two temperament dimensions, the average within-person mean was lower for negative affectivity (M = 3.72, SD = 1.17) than for orienting/regulation (M = 5.98, SD = 0.69), $t(125) = -16.66$, $p < .001$, $d = 2.34$. In contrast, the average within-person variability was higher for negative affectivity (M_{SD} = 0.81, SD_{SD} = 0.40) than for orienting/regulation (M_{SD} = 0.56, SD_{SD} = 0.42), $t(125) = 5.33$, $p < .001$, d = 0.55.

Whereas the within-person variability of negative affectivity and orienting/regulation was moderately correlated, r = .32, 95%-CI: [.15; .47], p = .002, both were unrelated to the

infants' age, gestational age at birth, and sex as well as the mothers' age, educational level, and migration background (for test statistics see online supplement on the OSF).

Discussion

Study 1 explored the extent of within- and between-person variability in infants' daily temperament. Results indicate substantial variance in the negative affectivity and orienting/regulation dimensions. Approximately 50% of the variance in each dimension could be attributed to the within-person level. Importantly, both temperament dimensions showed a high reliability on the between-person level and a satisfactory reliability on the within-person level. Thus, results support a trait component of infant temperament while also revealing a substantial state component.

Within-person variability was higher for negative affectivity than for orienting/regulation, which aligns with de Weerth et al.'s (1999) argument that emotional reactions like crying or fussing are an infant's means to communicate with their caregivers. Indeed, intra-individual variability in crying has been considered common in normally developing infants (St. James-Roberts & Halil, 1991) and it might covary with parenting practices (de Weerth & van Geert, 2001). Yet, neither daily variability in negative affectivity nor daily variability in orienting/regulation were related to descriptive characteristics of the infant (age, gestational age at birth, sex) or the mother (age, education, migration background), suggesting that variability in infant temperament might itself constitute in infant's characteristic.

Such a notion aligns with assumptions i that there are between-person differences in children's sensitivity to environmental stimulation (as a trait), implying between-person differences in within-person behavioral variation (e.g., regarding crying, soothability) (Belsky et al., 2007; Belsky & Pluess, 2009). We found an association between infant variability in daily negative affectivity and daily variability in orienting/regulation, which

could indicate a common underlying trait. Although higher state variability has typically been linked to higher trait neuroticism in adults (Eid & Diener, 1999), no conclusions can be drawn from the current study because no measures of infant trait temperament had been assessed. In addition, it was not assessed whether mothers actually interacted with their children during the day and some mothers might, therefore, have consulted their partners or other caretakers.

Study 2: Variability of Infant Temperament in Relation to Trait Measures

Study 2 aimed to replicate Study 1's findings and extend them in two ways: First, we included the third higher-order dimension of temperament (surgency) to study the full set of dimensions as described in Rothbart's conception of temperament. Second, we also included a baseline measure of trait infant temperament to investigate how the daily measures' mean level and variability relate to the standard trait measure of temperament. Finally, Study 2 addressed a methodological weakness of Study 1 by excluding daily reports if the mother had no contact with her child on the respective day.

The following preregistered hypotheses were tested in Study 2:

(1) Daily measures of infant temperament show substantial within-person and between-person variances. The variance decomposition of daily temperament measures in the present study is similar to that in Study 1.

(2) The within-person variance of daily temperament is larger for the temperament dimension negative affectivity than the temperament dimension orienting/regulation.

(3) Temperament states are substantially related to the respective temperament trait. In particular, we expect the convergent associations (e.g., aggregated negative affectivity states with negative affectivity trait) to be larger than the discriminant correlation (e.g., aggregated negative affectivity states with orienting/regulation).

(4) Within-person variance in daily (state) temperament (in all temperament dimensions) is positively related to the trait temperament dimension of negative affectivity.

Method

Participants. A total of 369 parents participated in Study 2. As preregistered, we included mothers (i.e., participants who identified as female) with infants aged 6 to 18 months who completed the baseline questionnaire and at least two of the ten daily surveys. Further inclusion criteria were that infants had to be born after 32 weeks of gestation. In addition, we excluded participants without variance on the baseline temperament measure and diary entries without variation (i.e., on a specific day, mothers chose the same response for all items). Deviating from the preregistration, also excluded all diary entries on days on which mothers reported having had no contact with their child. This resulted in a final sample of N = 199 German-speaking mothers of singleton infants. Mothers were M = 34.84 years old (SD = 4.13; range: 24–51). Infants were M = 12.97 months old (SD = 2.98, range: 6 to 18 months), 52.8% were boys, and 47.2% were girls. Most participants (n = 185, 93.0%) lived in Switzerland, and 55.3% had a migration background (i.e., were born outside of the country of residence). Overall, participants were highly educated (74.4% reported having completed a tertiary education degree) and reported a median household income of 8’700 CHF to 10’100 CHF (inter-quartile range: [6’400 CHF to CHF 7’500 CHF; 12’000 - 15’300 CHF])[1]. At the time of the survey, 82.4% of the mothers were working either full-time or part-time, whereas 17.6% were on maternity leave, unpaid vacation, or unemployed.

Procedure. Participants were recruited from August to November 2022[3]. The sample size was determined by the number of mothers who participated until November 15, 2022, but was also informed by considerations of statistical power. We aimed at recruiting at least 138 participants since this sample size would have allowed us to detect medium-sized

correlations ($r \geq .3$), which we expected between aggregated temperament states and traits, with a power of .95.

To recruit participants, we contacted parents who had given birth in the 18 months prior to the study at the REDACTED FOR BLIND REVIEW and who had provided general consent to be contacted for research studies. Due to a lower participation rate than expected from Study 1, we additionally used a database of parents recruited from birth registries in communities in and around REDACTED FOR BLIND REVIEW who had also given consent to be contacted for research studies. Therefore, the population in this database is highly comparable to the one recruited at the REDACTED FOR BLIND REVIEW. In addition, we advertised the study on social media platforms. Upon providing informed consent, participants completed a baseline online questionnaire. Starting the following evening, they were invited by e-mail to complete a diary survey every evening for 10 consecutive days, which took around 13 minutes. On average, mothers reported on their infant's temperament on 6.91 days (*SD* = 2.55; median: 7 days, $N_{\text{total observations}} = 1375$). Both the baseline and the daily diary survey contained additional measures not relevant to the aims of the present study.

Measures. *Trait infant temperament* was assessed by the German version of the IBQ (Gartstein & Rothbart, 2003; Putnam et al., 2014) used in the pilot phase of the NEPS (Bayer et al., 2015). This version assesses three higher-order temperament dimensions: negative affectivity (5 items, ω = .81), orienting/regulation (5 items, ω = .77), and surgency (5 items, ω = .56). Compared to Study 1, one additional item was added in the negative affectivity scale and the surgency dimension was additionally assessed. Items were answered on a 7-point Likert-type scale (ranging from 1 = "never" to 7 = "always") and referred to the previous seven days.

Daily infant temperament was assessed by an adaptation of the trait measure, parallel to Study 1. Items of the trait measure were adapted to refer to the respective day. Again, mothers could also indicate that an item did not apply on this day.

Data analyses. To test Hypotheses 1 and 2, intra-class correlations were calculated for each dimension of the state temperament measure. Intra-class correlations of this study were statistically compared to intra-class correlations from Study 1, limiting the analysis to the same set of items for this comparison. Equality of intra-class correlations was tested by comparing the 95%-confidence intervals of the ICCs derived from 5000 bootstrap samples. To test Hypothesis 3, we used linear regressions predicting the aggregated daily temperament scores (states) by the temperament traits. To test the robustness of these results, we used multilevel models predicting daily infant state temperament with infant trait temperament as a level 1 predictor. For all multilevel analyses, we centered person-level predictors around the grand mean. To test Hypothesis 4, we first computed the standard deviation of an infant's score across all daily measures of temperament. Following the suggestion by Baird et al. (2006) to account for the dependency of the standard deviations with the mean, we first predicted the within-person standard deviation by the associated within-person mean and the square of the within-person mean in a regression analysis. We then used the resulting residuals as dependent variables in a regression analysis with the trait temperament dimensions as independent variables. The item-level research questions were analyzed by the same methods, using individual temperament items instead of scales. Because they might potentially impact reports on infant temperament, the following variables were included in the analyses of Hypotheses 3 and 4 as covariates as preregistered: infant's age and sex, gestational age at birth (i.e., week of pregnancy), mother's age, mother's educational level (tertiary education: yes/no), and mother's migration background (yes/no). Multilevel analyses regarding Hypothesis 3 additionally included measurement time point (i.e., number of

completed daily assessments) to control for potential effects of repeated assessment. For robustness checks, all analyses have been repeated without covariates. All materials, analysis scripts, and supplementary analyses are provided on the Open Science Framework (https://osf.io/fb74t/?view_only=27907f4fcb94427ba1bf1fbc5a6a9a46).

Results

Hypothesis 1: Composition of Within- and Between-Person Variances of Daily Infant Temperament. Intra-class correlations for the present study indicated that 51% of the variance in daily negative affectivity, 95%-CI: [.43; .47]^2, 47% of the variance in daily orienting/regulation, 95%-CI: [.40; .53], and 41% of the variance in daily surgency 95%-CI: [.33; .48] could be attributed to differences between infants. The ICCs for negative affectivity and orienting/regulation were similar to the ICCs in Study 1. Likewise, as in Study 1, reliability estimates for negative affectivity and orienting/regulation were high on the between-person level (negative affectivity: ω = .86; orienting/regulation: ω = .93) and satisfactory on the within-person level (negative affectivity: ω = .66; orienting/regulation: ω = .70). However, reliability estimates were low for surgency (ω_{within} = .41 and $\omega_{between}$ = .44).

Hypothesis 2: Differences in Variability Across Temperament Dimensions. The temperament dimensions differed with regard to the within-person means, $F(2, 396)$ = 307.79, $p < .001$, and standard deviations, $F(2, 396) = 71.02$, $p < .001$. Bonferroni-corrected paired comparisons revealed that within-person means for orienting/regulation (M = 5.90, SD = 0.69) were higher than within-person means for surgency (M = 5.48, SD = 0.67), $p < .001$, d = 0.62, and negative affectivity (M = 3.98, SD = 1.08), $p < .001$, d = 2.14. Within-person means for surgency were also higher than within-person means for negative affectivity, $p < .001$, d = 1.65. The opposite pattern was observed for the within-person standard deviations. On average, within-person standard deviations were larger for negative affectivity (M = 0.86, SD = 0.37) than for orienting/regulation (M =

0.55, *SD* = 0.34), $p < .001$, $d = 0.89$, and surgency (*M* = 0.58, *SD* = 0.36), $p < .001$, $d = 0.78$. The average within-person standard deviations did not differ between the temperament dimensions orienting/regulation and surgency, $p = .60$, $d = 0.10$. Thus, regarding orienting/regulation and negative affectivity, the within-person means and standard deviations show the same pattern as in Study 1.

Hypothesis 3: Associations of Temperament Traits and Aggregated Temperament States. Table 1 displays the associations between the baseline trait measures of infant temperament and the aggregated state measures after controlling for covariates. For each temperament dimension, the convergent associations (i.e., the associations between the baseline temperament trait and its corresponding aggregated state) were higher than the divergent associations. However, the discriminant associations between both baseline negative affectivity (trait) and baseline orienting/regulation with aggregated surgency states were statistically significant, as was the association between baseline surgency (trait) and aggregated orienting/regulation (state). Robustness checks based on (1) multilevel models predicting daily temperament scores instead of the aggregated states and (2) basic correlations without covariates yielded the same pattern of results (see online supplement on the OSF).

Table 1

Convergent and Discriminant Associations Between Temperament Traits and Aggregated Temperament States

Baseline temperament trait	Aggregated temperament states		
	Negative affectivity	Orienting/regulation	Surgency
Negative affectivity	.51 [.38; .63]	-.11 [-.25; .04]	.19 [.05; .34]
Orienting/regulation	-.10 [-.25; .05]	.48 [.36; .61]	.18 [.03; .33]
Surgency	.08 [-.07; .23]	.31 [.17; .45]	.51 [.38; .64]

Note. The table displays standardized beta-coefficients from a linear regression controlling for infant age, gestational age at birth, and sex, as well as maternal age, education, and migration background. 95%-CI are given in brackets.

Hypothesis 4: Trait Negative Affectivity as a Predictor of Within-Person Variability. Like in Study 1, the within-person variability of the negative affectivity and orienting/regulation dimensions were correlated, $r = .33$, 95%-CI: [.20; .45], $p < .001$. In addition, we observed correlations between variability in negative affectivity and surgency, $r = .24$, 95%-CI: [.11; .37], $p < .001$, and between orienting/regulation and surgency, $r = .43$, 95%-CI: [.31; .53], $p < .001$. However, after controlling for differences in the temperamental state mean levels and the covariates, baseline (trait) negative affectivity was only related to within-person variability in surgency, $\beta = .16$, 95%-CI: [.02; .31], $p = .025$. There were no associations between baseline (trait) negative affectivity and to within-person variability in negative affectivity, $\beta = -.01$, 95%-CI: [-.16; .13], $p = .847$, or orienting/regulation, $\beta = .03$, 95%-CI: [-.11; .17], $p = .715$.

Exploratory Analyses on the Item Level. Exploring the characteristics of the daily temperament items yielded results similar to those from the daily temperament scales. In general, items on negative affectivity showed lower within-person means and a higher variability between days than items on orienting/regulation or surgency. Intra-class correlations numerically were somewhat smaller for items on negative affectivity or orienting than their respective daily temperament scales – probably indicative of higher reliability, and therefore less error variance, in scales compared to single items. However, this pattern could not be observed for items on surgency. Items on negative affectivity and orienting/regulation showed higher associations with their respective daily temperament scales (after removing

the specific items from the scales) than with the corresponding trait item or the corresponding temperament trait scale. In contrast, the associations for the daily surgency items did not display a clear pattern. To some extent, these partially low associations might be due to items that only infrequently could be observed daily. For instance, in almost 2/3 of the possible instances mothers rated the item on whether their infant laughed while being bathed as not applicable – most likely because the infant was not bathed that day. Likewise, in about 50% of the instances, mothers seem not to have left their infant in the crib, and in about 1/3 of the instances the mothers seem to have neither played cuckoo nor to have rhythmically cradled or rocked their infant. Thus, items varied in their suitability for daily assessments, in particular the items on surgency.

Table 2

Characteristics of Daily Temperament Items

	M_w (*SD*)	SD_w (*SD*)	% days 'not applicable'	*ICC*	r_{id}	r_{ii}	r_{it}
Negative Affectivity							
When your child was tired today, how often did they show signs of stress and discomfort?	3.94 (1.31)	1.23 (0.58)	8.44	.40 [.32; .47]	.64 [.52; .75]	.53 [.40; .66]	.33 [.19; .47]
As the exciting day ended today, did your child become whiny?	3.56 (1.33)	1.32 (0.64)	6.55	.32 [.25; .39]	.67 [.56; .79]	.33 [.19; .47]	.39 [.25; .53]
When you were busy doing something else today and your child was not able to get your attention, how often did they cry?	4.04 (1.28)	1.19 (0.56)	13.31	.38 [.30; .45]	.72 [.61; .82]	.42 [.28; .55]	.46 [.32; .59]
When your child couldn't have what they wanted today, how often did they get angry?	4.70 (1.34)	1.02 (0.51)	6.62	.51 [.44; .58]	.64 [.54; .75]	.41 [.27; .55]	.43 [.30; .55]
How often did your child seem angry (crying and fussing) when you left them in the crib?	3.45 (1.86)	1.22 (0.86)	55.71	.48 [.37; .57]	.57 [.42; .72]	.39 [.20; .58]	.42 [.25; .60]

Orienting/Regulation							
When your child was rhythmically cradled and rocked today, how often did they enjoy it?	5.83 (1.05)	0.85 (0.66)	28.80	.33 [.24; .41]	.60 [.48; .73]	.24 [.09; .39]	.36 [.21; .51]
When your child was rocked or hugged today, how often did they seem to enjoy it?	6.20 (0.68)	0.63 (0.45)	3.93	.33 [.25; .40]	.76 [.66; .86]	.41 [.28; .55]	.51 [.38; .64]
When your child was held in your arm or lap today, how often did they seem to be enjoying it?	6.05 (0.75)	0.66 (0.51)	2.04	.35 [.27; .42]	.69 [.58; .80]	.35 [.21; .50]	.32 [.18; .46]
When you sang to or talked to your child today, how often did they calm down right away?	5.69 (0.92)	0.79 (0.47)	9.53	.40 [.32; .46]	.70 [.59; .81]	.44 [.31; .58]	.40 [.26; .54]
When you gently patted your child today, how often did they calm down right away?	5.46 (1.20)	0.76 (0.53)	13.09	.50 [.42; .57]	.62 [.50; .73]	.55 [.43; .67]	.41 [.27; .54]
Surgency							
When your child was dressed or undressed today, how often did they squirm and/or try to roll away?	4.22 (1.56)	1.08 (0.64)	1.31	.58 [.51; .64]	-.05 [-.20; .09]	.53 [.40; .66]	.30 [.15; .44]

How many times has your child rapidly	5.84	0.73	15.93	.52	.35	.58	.35
approached new objects today?	(1.09)	(0.58)		[.45; .59]	[.20; .49]	[.45; .70]	[.20; .50]
When your child was put in the bath water today,	5.71	0.74	63.85	.59	.20	.53	.30
how many times did they laugh?	(1.68)	(0.80)		[.49; .68]	[.03; .36]	[.39; .67]	[.14; .46]
While playing cuckoo today, how many times has	6.40	0.46	29.67	.39	.28	.23	.13
your child laughed?	(0.86)	(0.46)		[.31; .47]	[.14; .43]	[.08; .38]	[-.03; .28]
When given a toy today, how many times has	5.73	0.73	5.89	.41	.23	.40	.36
your child smiled or laughed?	(0.81)	(0.47)		[.33; .48]	[.08; .37]	[.26; .53]	[.22; .50]

Note. N_{mothers} = 199; $N_{\text{total observations}}$ = 1375; M_w = mean within-person mean; SD_w = mean within-person standard deviation; *ICC* = intra-class correlation; r_{id} = correlation between aggregated state item and part-whole corrected aggregated corresponding state scale; r_{ii} = association between aggregated state item and corresponding trait item; r_{it} = association between aggregated state item and corresponding trait scale. r_{id}, r_{ii} and r_{it} reflect regression coefficients after controlling for infant age, gestational age at birth, sex, as well as maternal age, educational level, and migration background. Brackets include the lower and upper limits of a 95%-confidence interval

Discussion

Study 2 aimed to replicate the results from Study 1 and extend them by including the temperament dimension of surgency and a baseline trait measure of infant temperament. As in Study 1, about 50% of the daily variance in the infant temperament states of negative affectivity and orienting/regulation could be attributed to the between-person level. Also, within- and between-person reliabilities were similar to Study 1, indicating both a substantial trait component of infant temperament and a substantial state component. Furthermore, like in Study 1, variability was larger for negative affectivity than for orienting/regulation.

However, these results did not translate to temperament dimension surgency. Admittedly, the ICC for surgency was similar to the ICCs for negative affectivity or orienting/regulation. Still, both the reliability for the within- and the between-person level were low – reflecting the rather low reliability for surgency in the baseline trait measure. Low reliabilities for surgency had been reported before for German samples (Bayer et al., 2015; Sieber & Zmyj, 2022, Vonderlin et al., 2012) and might be due to some items not being adequately observable in the given timeframe. Indeed, mothers sometimes questioned the appropriateness of the timescales used in the questionnaires (Bayer et al., 2015). The results of the item-level analyses revealed that items related to the surgency dimension were frequently not applicable to the current day. For instance, a child does not get bathed every day, parents do not play ‘cuckoo’ every day, and some parents might not play ‘cuckoo’ at all. Thus, some items might not only be unsuitable for daily measurements, but these items can also result in low reliability (and validity) for standard trait measures of infant temperament.

Regarding construct validity, the convergent associations between aggregated state measures and the baseline trait measures were consistently larger than the discriminant associations for each scale. Thus, the data is in line with the assumptions of the whole trait theory. Item-level analyses further demonstrated that associations for aggregated items were

larger with the aggregated state scales than with the baseline trait measure. This might indicate that reliabilities for these temperament dimensions might be higher on shorter timescales, namely daily, than for a timespan "during the last seven days". This is supported by the between-person reliabilities for negative affectivity and orienting/regulation, which were higher than those for the baseline trait dimensions. Thus, these results extend previous research arguing that the stability of temperament measures usually decreases with the length of the time interval between assessments (Bornstein et al., 2015; Stifter & Dollar, 2016) to the daily level.

Within-person variability was correlated across scales suggesting a common underlying factor. However, contrary to our expectations and previous results from adult personality (e.g., Eid & Diener, 1999), trait negative affectivity as a precursor of neuroticism did not explain within-person variability except for the surgency dimension. One reason could be that during infancy, negative affectivity not only reflects a neuroticism-like trait but crying, fussing, and whining also serve as a way of communication (de Weerth et al., 1999). In addition, infants depend on their caregivers not only with regard to meeting their needs but also with regard to regulating their emotions (Pauen & EDOS Group, 2016; Taipale, 2016). During the first year of life, parents learn how to adequately respond to their infant's signals. They improve their soothing strategies and sort out strategies that did not work (Dayton et al., 2015). This changes the frequency of infant crying and how easily an infant can be soothed. Thus, in infants, negative affectivity might not be as predictive for variability across temperament dimensions as a developed personality trait like neuroticism has been for variability in adult personality.

General Discussion

The present studies addressed the variability of infant temperament when measured by daily mother reports. Study 1 demonstrated that there was both substantial within- and

between-person variability, and Study 2 replicated these findings and further showed that daily measures of infant temperament systematically relate to trait measures.

Our first – primarily descriptive – aim was studying the within-person and between-person variance in daily measures of infant temperament. We found evidence that around 50% of the variance in daily measures of infant temperament can be attributed to between-person differences. To put these numbers into perspective, we can compare them to studies on variability in infant behavior and variability in child and adult affect. Regarding infant behavior, James-Roberts and Plewis (1996) found that within-person variability also accounted for around half (44% to 53%) of the variability in sleeping, fussing, and crying from day to day. Our results regarding temperament states are comparable to these results. It seems that infant behavior – whether described on a more basic level or as a state expression of temperament – is characterized by variability and relatively stable individual difference. The results are also similar to results on daily affect in children and adults. In elementary school children, within-person variability accounted for 45-66% of the variance in daily positive affect, negative affect, and interest over one month (Könen et al., 2016). In adults, within-person variability accounted for 46% of the variance daily negative affect over eight consecutive days (Mroczek et al., 2003).

We compared the degree of variability across daily measurements for the three broad dimensions of temperament (negative affectivity, orienting/regulation, and surgency). Overall, negative affectivity showed a larger amount of within-person variability than orienting/regulation (Studies 1 and 2) and surgency (Study 2). One possible explanation considers infant negative affectivity, particularly with regard to crying, whining, and fussing, not only as an infant's characteristic but also as an infant's way of communicating their needs (de Weerth et al., 1999). Thus, variability in negative affectivity is part of normal development (de Weerth et al., 1999; St. James-Roberts & Halil, 1991) but might decrease

with the infant's age as communication between infants and their caregivers advances, infants develop the ability to self-sooth, and more stable characteristics emerge (Pauen & EDOS Group, 2016). In this study, we did not observe any associations of age and variability in infant state temperament. Still, as the sample size did allow us to analyze more complex age effects, this question remains open.

Our second overarching aim was to apply whole trait theory (Fleeson & Jayawickreme, 2015, 2021) to infant temperament by investigating the extent to which state ratings of infant temperament align with trait ratings. We found that there were strong convergent associations between aggregated temperament states and their corresponding temperamental trait, which were consistently larger than the discriminant associations with different temperamental traits. This suggests that whole trait theory can be applied to infant temperament as precursors of personality traits.

Since there is considerable within-person variability, especially for negative affectivity, it is important to consider both the mean level of temperament and its variability. For instance, crying, whining, and fussing are a normal part of infant development; however, it is prolonged and excessive crying – that is high levels of negative affectivity with low variability across days – is clinically relevant and might lead to long-term behavior problems (Hemmi et al., 2011; Zeifman & St James-Roberts, 2017).

Our third aim was to expand knowledge on the role of time scales in assessing infant temperament and, specifically, to provide information on which infant behaviors are observable on a daily basis. We found that several items used were not easily observable. Seven of the 15 items were rated as not applicable to the present day more than 10% of the time, five of these (1 item assessing negative affectivity, 1 item assessing orienting/regulation, and 3 items assessing surgency) more than 25% of the time, and two of these items ("How often did your child seem angry (crying and fussing) when you left them

in the crib?" and "When your child was put in the bath water today, how many times did they laugh?") were even rated as not applicable more frequently than they were answered (i.e., more than 50%).

We also tested the correspondence between each item answered using the trait instruction ("during the last seven days") at baseline and aggregated across up to 10 days using the state instruction ("today"). Overall, we found a relatively high convergence between these two measures but also considerable variation. If we assume a relative stability of the behaviors assessed in the IBQ, which is supported by both our results and previous work on the test-retest reliability of the scale (Bornstein et al., 2015; Putnam et al., 2014; Worobey & Blajda, 1989), this convergence might be informative about the extent to which parent ratings in the trait version reflect what they observe in their infant's daily behavior. For some items, this convergence is relatively low, and it is conceivable that for these items, the validity of the assessment could be improved by assessing it daily, allowing parents to report on their more immediate observations instead of recalling their infants' behavior from several days ago.

Implications for the Assessment of Temperament

Our findings have implications for the assessment of infant temperament. First, given the between-person differences we observed and the convergence between aggregated state measures and trait measures, it seems that daily measures of infant temperament generally tap into relatively stable individual differences. In fact, the convergence between aggregated state measures and the respective trait measures surpassed values reported for adults (e.g., Rauthmann et al., 2019). Thus, our results imply that infant temperament can also be assessed at the daily level.

However, our findings raise concerns about some of the items in the IBQ, one of the most widely used parent questionnaires for evaluating infant temperament (Gartstein &

Rothbart, 2003; Putnam et al., 2014). Firstly, some of the IBQ items were not observable on a daily basis. In the IBQ, parents are asked to report how often their infant has displayed a specific behavior in the past week. Our study suggests that parents may have had limited opportunities to observe some behaviors, sometimes only once or twice per week, or even not at all, which questions whether the item can accurately reflect the infant's behavior. Therefore, we suggest carefully examining the situational conditions described in temperament items (e.g., leaving the child in the crib, bathing the child) and determining whether these situations occur frequently enough for parents to report them in the given timeframe meaningfully. The frequency of such situational conditions might also vary substantially across time and cultures.

Second, we observed that the means of some items assessing state orienting/regulation and state surgency, were relatively high, i.e., close to or above 6 on a 7-point answer scale. In contrast, the means of the items assessing negative affectivity were closer to the scale midpoint. This suggests that some orienting/regulation and surgency items might be less able to differentiate between infants with high trait levels and that the relatively high means may limit our ability to observe variability. We conclude that analyzing the item characteristics of state assessments can be informative for trait measures, particularly those using short timescales.

Theoretical Implications

With the present studies, we responded to recent calls to apply insights from personality dynamics, specifically whole trait theory, to developmental psychology (Dykhuis et al., 2023). Our findings support the idea that whole trait theory can indeed be applied throughout the lifespan since also in our sample of infants aged 6 to 18 months, we found temperament states and variability to be meaningful and, if aggregated, to converge with trait temperament. Like adult personality, infant temperament displays consistency over time and

varies within-person across days. Of course, the present effort can only be a start in bridging personality dynamics and developmental psychology, but our results are a promising starting point for the upcoming steps.

In developmental psychology, within-person variability is often seen as an indicator of long-term intra-individual change (Nesselroade, 1991). As such, within-person variability should be higher during life transitions or might be indicative of sensitive developmental periods, in which the environment has a stronger impact on development (Walasek et al., 2022). Infancy and early childhood have been considered sensitive periods, particularly with regard to parental co-regulation (e.g., by calming down a crying infant) and the long-term development of self-regulation (Sullivan & Opendak, 2020).

Within-person variability might not only reflect sensitive periods, but it might also indicate to what extent infants are sensitive to the environment. Between-person differences in how infants react to various environments (e.g., parenting); Belsky et al., 2007; Belsky & Pluess, 2009) imply between-person differences in within-person behavioral variability. In addition, it implies stronger within-person couplings of infant behavior (e.g., negative affectivity) and the environment (e.g., parenting behavior). To analyze such relationships, reliable measures of infant behavior (e.g., temperamental states) are a prerequisite

Limitations

Several limitations of the present studies should be mentioned. First, our samples only comprised mothers and mainly consisted of low-risk families with high socio-economic status. Both parents' gender and education are related to the measurement of infant temperament (e.g., Casalin et al., 2012; Parade & Leerkes, 2008), and these characteristics limit the generalizability of our results. Likewise, our sample consisted of German-speaking mothers primarily living in Switzerland. Thus, the findings might not readily translate to other languages or cultural contexts.

Second, since we wanted to learn how mothers respond to standard temperament items when assessed at a daily level, we used a small set of temperament items that had not been developed for daily assessments. Our results showed that not all these items are suitable for daily assessments since they describe situations that do not typically occur daily. In addition, the 9 (Study 1) or 15 (Study 2) items focus on the three broad dimensions of negative affectivity, orienting/regulation, and surgency and do not lend themselves to more fine-grained analyses of narrower temperament dimensions. Future studies should try a broader range of items (e.g., from the long version of the IBQ) to find the items best suited for daily assessments while still reflecting all temperament dimensions and considering general guidelines for the assessment of personality states (e.g., Horstmann & Ziegler, 2020).

Third, our sample included mothers of infants aged between 6 to 18 months, covering a relatively broad age range within infancy. It is possible that the variability of temperament changes across this period. Although we used age as a covariate in our analysis, our sample size did not permit a more comprehensive examination of potential age effects, such as the trends documented by de Weerth et al. (1999), who showed that within-person variability in crying decreased after the age of ten months.

Conclusion

Both studies found substantial within-person variability in infant temperament, along with a strong trait component. The convergence between aggregated temperament states and trait measures of temperament suggests that whole trait theory can be applied during infancy. However, some items, particularly those related to surgency, were not applicable on a daily basis, which could impact the reliability and validity of commonly used trait measures of infant temperament.

Notes

[1]To account for different currencies and spending powers in Switzerland, Germany, and Austria, income categories were derived from the European Social Survey 2018 (ESS Round 9: European Social Survey, 2021) and converted into CHF.

[2]To compare the ICC to the ICC in Study 1, the analysis was repeated with the same items as in Study 1. This resulted in an ICC = .49, 95%-CI: [.42; .55].

[3]We had originally preregistered to end recruitment by the end of August 2022. Since there were delays in the data collection and participation rate was lower than anticipated based on Study 1, we decided to use a second recruitment strategy and to prolong data collection until November 15, 2022. This allowed us to reach the anticipated sample size of around 200 participants who completed the daily diary (N = 199).

Open Science Statement

Data for Study 1 are published on Zenodo (https://doi.org/10.5281/zenodo.6946048), and data for Study 2 are available on the Open Science Framework (https://osf.io/fb74t/?view_only=27907f4fcb94427ba1bf1fbc5a6a9a46). In addition, we provide all materials (e.g., the original wording of instructions and items) as well as the R scripts underlying all analyses presented.

Ethics Statement

The ethical board of the REDACTED FOR BLIND REVIEW reviewed the study protocol and considered the study uncritical.

CRediT Author Statement

Tilman Reinelt: Conceptualization, Investigation, Data Curation, Formal analysis, Writing - Original Draft, Writing – Review and Editing; Lisa Wagner: Conceptualization, Investigation, Formal analysis, Writing - Original Draft, Writing – Review and Editing. Debora Suppinger: Investigation, Writing – Review and Editing; Moritz M. Daum: Writing – Review and Editing; Giancarlo Natalucci: Writing – Review and Editing.

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Declaration of Interest Statement

We have no known conflict of interest to disclose.

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