


## Special Issue Article

# Person-centered methods to advance developmental psychopathology

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### Abstract

Dante Cicchetti's remarkable contributions to the field of developmental psychopathology include the advancement of key principles such as the interplay of typical and atypical development, multifinality and equifinality, the dynamic processes of resilience, and the integration of multiple levels of analysis into developmental theories. In this paper we assert that person-centered data analytic methods are particularly well-suited to advancing these tenets of developmental psychopathology. We illustrate their utility with a brief novel empirical study focused on underlying patterns of childhood neuroendocrine regulation and prospective links with emerging adult functioning. Results indicate that a childhood neuroendocrine profile marked by high diurnal cortisol paired with low diurnal DHEA was uniquely associated with more adaptive functioning in emerging adulthood. We discuss these findings, and person-centered methods more broadly, within the future of developmental psychopathology.

**Keywords:** cortisol; DHEA; developmental psychopathology; maltreatment; person-centered methods

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Dante Cicchetti's pioneering work in the field of developmental psychopathology includes the advancement of central tenets such as the interplay of typical and atypical development (Cicchetti, 1984), multifinality and equifinality (Cicchetti & Rogosch, 1996), attention to resilience in the face of adversity (Luthar et al., 2000), and the integration of interdisciplinary multiple levels of ecology into developmental theories and models (Cicchetti & Valentino, 2007). These core principles have guided the field and led to an explosion of knowledge generation since his 1984 guest editorial in *Child Development*, "The emergence of developmental psychopathology" (Cicchetti, 1984).

Person-centered data analytic methods, including latent class (LCA) and profile analysis (LPA), latent transition analysis, and growth mixture modeling (GMM), aim to identify unobserved, hidden, or latent subgroups of individuals within a sample that share a similar pattern on a set of observed variables. These methods are also known as finite mixture models. Person-centered methods offer an important data-driven approach to capturing and unpacking heterogeneity within a sample (Collins & Lanza, 2009; Lanza & Cooper, 2016) and contrast with more traditional variable-centered approaches, such as multiple regression, which emphasize mean associations between predictor and outcome variables.

The purpose of this paper is to highlight and illustrate the utility of person-centered methods within developmental psychopathology. There are several useful resources currently available on the

mathematical underpinnings of person-centered data analysis, how to conduct these analyses, and applications and advances (e.g., Bergman et al., 2015; Collins & Lanza, 2009; Goodman, 1974; Hagenars & McCutcheon, 2002; Hancock et al., 2019; Lanza & Cooper, 2016). We refer readers to these helpful resources and instead focus our attention on the application and utility of person-centered approaches within developmental psychopathology, its central tenets, and its future.

### Developmental psychopathology principles and person-centered methods

#### Typical and atypical development

A key principle of developmental psychopathology research and theory is that we can "learn more about the normal functioning of an organism by studying its pathology and, likewise, more about its pathology by studying its normal condition" (Cicchetti, 1984, pp. 1). This succinctly stated premise has reoriented research psychologists, focused on normative development, and clinical psychologists, focused on pathology, toward the shared goal of conceptualizing typical *and* atypical developmental functioning and contexts across domains and throughout the lifespan. Delineation of typical and atypical processes in developmental psychopathology applies to both the developing individual, as well as the environment in which that person develops. Seminal work from the Mt. Hope Family Center at the University of Rochester has led to careful operationalization of the construct of child maltreatment within a developmental psychopathology framework (see Barnett et al., 1993) and has yielded multiple decades of

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research illuminating the impact of maltreatment on typical and atypical development.

Contending with the heterogeneity within and between typical and atypical processes represents a sizable challenge. In the example of child maltreatment exposure, person-centered approaches are a useful tool because they allow for consideration of multiple maltreatment dimensions (e.g., chronicity, developmental timing, subtype) concurrently. By capturing naturally occurring heterogeneity across these interrelated dimensions, maltreatment can be characterized as it occurs in the lives of children, rather than requiring researchers to test the unique effect of specific individual exposures, controlling for others.

The utility of person-centered methods for capturing heterogeneity within maltreatment exposures is illustrated by the work of Villodas et al. (2012), who characterized common patterns of maltreatment exposure within developmental epochs and found that multi-subtype exposures commonly recur in subsequent developmental periods. Applying a person-centered approach to characterize maltreatment exposure has gained ground in recent years, resulting in a body of research that suggests that maltreatment exposures *commonly* co-occur, further advancing the field's understanding of the variation and breadth of exposures represented by child maltreatment. Evaluating the patterning of maltreatment exposures, as opposed to single subtypes, has subsequently advanced knowledge about the types of maltreatment patterns that increase odds of maladaptation across functional domains (e.g., multi-subtype or chronic exposure; Villodas et al., 2012; Warmingham et al., 2019; for review see Rivera et al., 2018). Thus, person-centered methods allow researchers to tackle some of the limitations of specificity models, including lack of clear distinction between forms of maltreatment, the tendency for maltreatment subtypes to co-occur, and the lack of evidence for specific effects from various unique forms of maltreatment (Smith & Pollak, 2021).

### Multifinality and equifinality

Multifinality explains how similar originating events, experiences, or processes in development can set forth unique developmental cascades, leading to a diversity of developmental outcomes across individuals (Cicchetti & Rogosch, 1996). In contrast to multifinality, equifinality refers to the diversity of developmental processes that may result in a singular outcome. Child maltreatment, though inarguably a severely threatening event in child development, does not uniformly result in maladaptation (Cicchetti & Toth, 2016). Further, exposure to child maltreatment may set in motion a host of processes resulting in a wide array of symptomology including but not limited to externalizing problems (e.g., aggression), internalizing problems (e.g., depressed mood or anxiety), and substance use problems that may be present at various developmental periods in the life course (e.g., Kim-Spoon et al., 2013; Rogosch et al., 2010; Russotti et al., 2021; Vachon et al., 2015).

Multifinality in development is a complex theoretical principle that requires methodological and statistical approaches that are appropriately matched. Person-centered approaches are well-suited to the task. These data-driven methods allow researchers to “elucidate processes contributing to divergence in outcomes given common origins” (Cicchetti & Rogosch, 1996, pp. 598). Variable-centered approaches summarize mean associations between variables and in doing so, do not capture the nuanced heterogeneity inherent to developmental processes, thus limiting

their exclusive ability to advance understanding of developmental processes marked by significant heterogeneity in origin, trajectory, or outcome (Cicchetti & Rogosch, 1996).

Person-centered approaches to studying multifinality and equifinality can elucidate (a) heterogeneity in process and (b) heterogeneity in outcomes. First, pairing person-centered approaches with longitudinal designs (e.g., growth mixture modeling (GMM)) allows for the examination of multifinality in processes over time. For instance, in a sample of adolescents with prior exposure to child maltreatment, investigators used GMM to find unique developmental trajectories of future orientation (a resilience-promoting characteristic defined as having a positive outlook towards the future; Oshri et al., 2018). The three patterns of future orientation development over time included a *high start/decreasing* group, a *high-persistent* group, and a *low start/increasing* group (Oshri et al., 2018). These developmental trajectories of future orientation were, in turn, related to unique outcomes in young adulthood including psychopathology (e.g., substance use and internalizing) and stage-salient developmental tasks (e.g., employment and independent living skills; Oshri et al., 2018). Here, the person-centered GMM approach was necessary to clarify multifinality in the processes of future orientation, which then contributed to knowledge of resilient processes in development.

Person-centered approaches can also unpack heterogeneity in outcomes. For instance, Duprey et al. (2023) used a latent profile analysis (LPA) to extract different profiles of psychopathology in a sample of emerging adults with and without child maltreatment exposures. Results revealed three unique profiles marked by different patterns of internalizing and externalizing psychopathology and illustrate how person-centered methods can assist developmental psychopathologists in uncovering heterogeneity of psychopathology presentations.

### Resilience

In line with the principle of multifinality, developmental psychopathologists are often interested in understanding the interaction between vulnerability and protective factors occurring at all levels of ecology to yield patterns of adaption and maladaptation following the same risk exposure (Cicchetti & Rogosch, 1996). Resilience is a dynamic process that includes the manifestation of positive adaptation and competent functioning for an individual, despite experiences of significant adversity (e.g., child maltreatment) and major assaults on development (Luthar & Cicchetti, 2000; Luthar et al., 2000; Masten et al., 1990). Importantly, resilience is a complex, multidimensional construct and individuals displaying resilience may do so in some spheres of functioning at certain developmental periods, rather than universally across development, or universally across domains (Cicchetti, 2013; Luthar et al., 2000; Masten & Tellegen, 2012). There is typically notable heterogeneity in resilient outcomes, such that perturbations in one developmental domain do not preclude adaptive functioning in another (Luthar et al., 2000).

Identifying naturally occurring patterns of positive adaptation addresses a central principle of a developmental psychopathology framework of resilience—that competence in one domain of functioning only gains meaning in relation to the individual's functioning in other developmental domains (Bergman & Magnusson, 1997; Cicchetti, 2013; Luthar et al., 2000; Masten, 2001). Rather than determining resilient functioning based on single domains of functioning, person-centered approaches can discern and describe unobserved subgroups of individuals who

may present with heterogeneous patterns of adaptive and maladaptive functioning across multiple developmental domains or developmental periods (Bergman & Magnusson, 1997; Lanza & Cooper, 2016), thus matching the theoretical conceptualization of resilience.

We offer a few examples of the utility of person-centered approaches to resilience following child maltreatment exposure. Using LCA in a longitudinal cohort study of children with maltreatment exposure, Russotti et al. (2020) identified latent profiles of multi-domain psychosocial resilience in emerging adults. Results identified a group exhibiting multifaceted positive adaptation, multifaceted maladaptation, and two groups with mixed patterns of adaptation and maladaptation. Notably, children with maltreatment exposures were less likely to experience multifaceted adaptation and more likely to exhibit aggregated maladaptation than their non-maltreated peers. Additionally, findings indicated that Black men who demonstrated a pattern of multifaceted psychosocial competence following adversity also evidenced higher levels of physiological distress, suggesting psychosocial adaptation may impart a biological toll for some individuals.

### Multiple levels of analysis

According to Cicchetti and Valentino (2007), “in order to grasp fully the complexity inherent to the examination of the . . . human mind, it is important that a multiple-levels-of-analysis approach and an interdisciplinary perspective be incorporated into the research . . . of developmental psychopathologists.” The ecological-transactional model (Lynch & Cicchetti, 1998) emphasizes four levels of analysis: macrosystem (cultural beliefs/values), exosystem (community, neighborhood), microsystem (within-family factors), and ontogenic development (within-person factors such as biological and psychological development). Person-centered data analytic methods are extremely well-suited to the integration of multiple levels of analysis within a single study. Rather than pitting individual levels of ecology against each other in a variable-centered approach, person-centered methods allow for a holistic “unpacking” of heterogeneity within and across levels to identify meaningful patterns across various systems. This unpacking then facilitates an investigation of how hidden, or latent, multi-level patterns differentially relate to the development of adaptation and maladaptation. By identifying naturally occurring patterns across myriad systems, a person-centered approach may more accurately and holistically capture heterogeneity within communities, families, and within biological systems within-persons.

For example, allostatic load refers to the cumulative multi-level biological toll of stress on the body (McEwen, 2012), and is typically indexed by a range of biomarkers across multiple systems (e.g., HPA axis, parasympathetic nervous system, cardiovascular system). Person-centered data analytic methods are uniquely poised to capture variability across multiple systems to index allostatic load (e.g., Beijers et al., 2019; Carbone, 2021; Forrester et al., 2019). For instance, Carbone (2021) utilized LCA to identify four classes of multi-system dysregulation and found that individuals who demonstrated either a pattern of metabolic and immune dysregulation or a pattern of parasympathetic dysregulation were more likely to experience depression. Extending this beyond allostatic load, Bendezú et al. (2022) illustrated the utility of LPA to capture multiple levels of ecology by identifying four distinct profiles of neuroendocrine, inflammatory, and neuro-cognitive processes, and showing associations with child

maltreatment exposure and depressive symptoms. Additionally, Hoyt et al. (2021) employed a person-centered approach to identify latent subgroups on five indices of regulation of the stress hormone, cortisol. These measured indicators included area under the curve (AUC), cortisol awakening response (CAR), diurnal slope, and waking and bedtime levels. Results suggested five latent patterns of cortisol regulation with one specific pattern (i.e., flat slope, high AUC, and high CAR) being most strongly linked with negative mental health outcomes. Thus, person-centered models, because of their ability to holistically capture latent patterns across multiple systems, represent an important tool for integrating multiple levels of analysis into developmental psychopathology models.

### Empirical study

We now turn to a brief novel empirical study to illustrate the utility of person-centered methods for advancing developmental psychopathology. We focus on the application of these methods to the study of neuroendocrine regulation/dysregulation and links with child maltreatment exposure and developmental outcomes because this is a substantive area in which Dante Cicchetti has made a major impact. Child maltreatment, including physical, sexual, and emotional abuse, and neglect, represents a severe pathological departure from the average expected caregiving environment and has been associated with a host of negative biopsychosocial sequelae that occurs along with dysregulation of the stress response system (Cicchetti & Toth, 2016). However, results of prior studies examining the impact of maltreatment on neuroendocrine regulation are decidedly mixed, potentially due to differences across studies in the timing/recency of the maltreatment exposures, heterogeneity in the types of maltreatment exposures, differences in the methods of indexing cortisol regulation, and the common practice of relying on a single index of HPA axis regulation. Person-centered methods represent an important advance in the simultaneous examination of multiple indicators of the neuroendocrine functioning and may facilitate a more nuanced understanding of the impact of adversity, and maltreatment specifically, on HPA axis dysregulation and the development of psychopathology.

Handley et al. (2023) demonstrated the usefulness of latent profile analysis in capturing heterogeneity in both diurnal cortisol and diurnal dehydroepiandrosterone (DHEA), an adrenal steroid with anti-glucocorticoid properties that may function to protect from high levels of cortisol (Charney, 2004). Among a sample of 1,258 children experiencing poverty, aged 8–12, Handley et al. (2023) identified four naturally occurring profiles of diurnal cortisol and DHEA. Interestingly, girls who experienced more pervasive child maltreatment were more likely to evidence a profile of high cortisol paired with low DHEA suggesting a potential imbalance across these hormonal systems. Moreover, children who displayed a profile of relatively average cortisol paired with high DHEA were more likely to experience internalizing symptoms. This study advanced prior research by integrating a person-centered approach with the study of the physiological underpinnings of stress regulation among children exposed to maltreatment, and by demonstrating contemporaneous associations between profiles of neuroendocrine regulation and mental health and resilience. However, the question of whether these naturally occurring childhood patterns of cortisol and DHEA regulation influence adaptation later in development remains unknown. The aim of the current empirical study was to investigate prospective

links between established childhood cortisol/DHEA profiles and emerging adult adaptation and maladaptation (e.g., mental health, substance use, interpersonal competence, and motivational systems). We selected these domains because they have been conceptually and empirically linked with child maltreatment and neuroendocrine regulation. Due to the explanatory nature of the empirical study within this commentary on the utility of person-centered methods for developmental psychopathology, we are necessarily abbreviated in our description of the empirical study.

## Method

### Participants

Participants in the current study were part of a larger, pooled dataset (R03HD103779;  $N = 1,165$ , see Handley *et al.*, 2023 for details) containing two separate samples of  $N = 686$  (R01DA017741) and  $N = 479$  (R01MH083979) children who participated in a research-based summer camp during the years 2004–2012 (W1; see Cicchetti and Manly, 1990 more information about the research camp setting). The combined sample resulted in 1,165 children aged 8–13 (50.8% male;  $M_{age} = 10.44$   $SD = 1.32$ ). Participants were racially and ethnically diverse (70% Black, 23% white, 5% biracial, 2% other race; 16% Latinx) and had histories of receiving public assistance (98.2%). The sample included children exposed to maltreatment ( $n = 609$ ; 53.5%) and children without maltreatment exposures ( $n = 529$ ; 46.5%).

One of the respective research summer camp studies (R01DA017741) was designed to follow child participants longitudinally into emerging adulthood. The individuals from this specific cohort are the focus of the current empirical study (W1:  $N = 686$  children;  $n = 364$  children exposed to maltreatment;  $n = 322$  children without maltreatment exposures;  $M_{age} = 11.27$ ,  $SD = .97$ ; 71.2% Black, 12.2% White, 12.6% Hispanic, 4.0% biracial/other race; 50.5% male). The majority of children were from single parent families (68.7%) with a history of receiving public assistance (96.1%). At wave 2 (W2), participants were recontacted during emerging adulthood. Emerging adults were on average 19.67 years old ( $SD = 1.16$ ), 51.1% female, and 53.2% experienced maltreatment in childhood. The current study included  $N = 427$  participants who completed both waves of data collection. Participants who completed W2 did not differ from participants who completed W1 on maltreatment status ( $\chi^2(1) = .32$ ,  $p = .57$ ), sex ( $\chi^2(1) = 1.25$ ,  $p = .27$ ) or cortisol/DHEA profiles ( $\chi^2(3) = 2.72$ ,  $p = .44$ ).

### Procedures

W1 participants were recruited for a summer research camp from 2004–2007. Children in the maltreated group had substantiated investigations of child maltreatment according to Department of Human Services (DHS) Child Protective Services (CPS) records. Children without CPS involvement were recruited from families receiving Temporary Assistance to Needy Families to ascertain a sociodemographically-comparable sample of children without maltreatment experiences. A DHS liaison identified eligible families and contacted a random sample from both groups via mail. Participation was voluntary. If families elected to participate, their contact information was shared with research staff. The demographics of families who declined participation were not disclosed by DHS. Further, trained research staff conducted the Maternal Child Maltreatment Interview (Cicchetti *et al.*, 2003) with all mothers to confirm the absence of maltreatment. If any

conflicting information was provided that suggested the non-maltreated participants may have experienced maltreatment, they were excluded from the comparison group.

Parents who chose to enroll their children in the research summer camp provided signed consent to study procedures. During the week of summer camp, camp counselors facilitated recreational activities with the same groups of 8–10 children (35 hours of direct contact and observation). Children also provided assent to study procedures. Children self-reported on their functioning and camp counselors provided independent ratings of childhood functioning after the end of the week. Maltreatment status was unknown to camp counselors.

At W2 (~eight years after W1), a variety of strategies were used to relocate and recruit W1 participants for a follow-up study during emerging adulthood. Records of last known addresses, extensive public internet searches (e.g., LexisNexis), contact information from medical records, and neighborhood canvassing were part of a comprehensive recruitment design. Interested participants completed signed consents and then participated in three research visits.

## Measures

### Salivary cortisol and DHEA

At W1, saliva samples were obtained by trained research assistants at daily, uniform times across the camp week: (1) at 9 a.m. upon arrival; (2) at 12 p.m. before lunchtime, and (3) at 4pm upon departure. Research staff ensured that no food or drink was consumed for at least 30 minutes prior to each saliva sample. Due to the transportation time and initial time spent being greeted to camp, children had been awake for at least one hour before providing the morning saliva samples, resulting in a measure of morning cortisol that did not include awakening response. There was no reason to suspect waking times systematically varied across children. Samples were collected following recommendations by Granger *et al.* (1999). Children chewed Trident® sugarless gum to stimulate saliva flow and then passively drooled through a short drinking straw into a 20 ml plastic vial. Samples were frozen at  $-80^{\circ}\text{C}$  for temporary storage and then, each week, were shipped overnight on dry ice for next day delivery to Salimetrics Laboratories (State College, PA) for assay. After thawing, each sample was processed by placing four to five 1 ml aliquots into 1.8 ml cryogenic storage vials and frozen at  $-40^{\circ}\text{C}$ . Upon assay, samples were thawed to room temperature and centrifuged at 3000 r.p.m. for 15 minutes. The clear top plastic of the sample was pipetted into appropriate test tubes/wells. Salivary cortisol (in micrograms/deciliter) was assayed using an enzyme immunoassay kit (Salimetrics, State College, PA). This kit is commercially available and uses 25  $\mu\text{l}$  of saliva. Its lower limit of sensitivity is 0.007  $\mu\text{g}/\text{dl}$  (range up to 1.8  $\mu\text{g}/\text{dl}$ ) with average intra- and interassay coefficient of variation of  $< 5.0$  and 10.0% respectively. Cortisol was assayed from saliva for each day across the week that it was collected. Salivary DHEA (in picograms/milliliter) was also processed using an enzyme immunoassay kit (Salimetrics, State College, PA). This kit uses 550  $\mu\text{l}$  of saliva. Its lower limit of sensitivity is 10.0 pg/ml (range up to 1000 pg/ml) with average intra- and interassay coefficient of variation of  $< 5.0$  and 15.0%, respectively. DHEA was assayed from saliva collected from two days, Tuesday and Thursday, because of less variability in DHEA levels.

Cortisol and DHEA were checked for out-of-range values (cortisol  $< .012$  or  $> 3.00$   $\mu\text{g}/\text{dl}$ ; DHEA  $< 10.2$  or  $> 1000$  pg/mL),



and out-of-range values were recoded as missing. Data were then checked for outliers  $\pm 3$  SD and were subsequently winsorized by recoding outliers to the value at  $\pm 3$  SD from the mean. To calculate morning (i.e., AM) values, cortisol and DHEA were averaged across the week for each participant. To compute diurnal change in cortisol and DHEA, AM and evening (i.e., PM) values were averaged for each participant across the week. A difference score was then computed for each participant (AM value–PM value). Higher diurnal scores represent a steeper decline in hormone levels from morning to evening. Area under the curve (AUC) for cortisol and DHEA was calculated using hormone data collected throughout each day. Before computing the AUC, values were averaged across the week for each time of day. The AUC score was calculated using Formula 2 (i.e., AUC with respect to ground) from Pruessner et al. (2003).

### Maltreatment

The Maltreatment Classification System (MCS; Barnett et al., 1993) was used to code CPS records from birth until age 12. Children were dichotomously categorized as (1 = exposure to maltreatment; 0 = no maltreatment exposure).

### Outcomes

The behavioral inhibition/behavioral activation scale (BIS/BAS; Carver & White, 1994; Cooper et al., 2007) is a self-report measure designed to assess individual differences in two general motivational systems posited to underlie behavior and affect: (1) behavioral approach system (BAS), which is believed to regulate appetitive motives that drive individuals toward something desired; (2) behavioral avoidance (or inhibition; BIS), which is theorized to regulate aversive motives intended to avoid unpleasant stimuli (Carver & White, 1994). The BIS/BAS has one BIS scale (7 items; e.g., “even if something bad is about to happen to me, I rarely experience fear or nervousness”) and three BAS scales: Reward Responsiveness (5 items; e.g., “when I’m doing well at something I love to keep at it”), Drive (4 items; e.g., “I go out of my way to get things I want”) and Fun Seeking (4 items; e.g., “I’m always willing to try something new if I think it will be fun”). Each item is rated on a scale of 1 (very true for me) to 4 (very false for me). Higher scores on the BIS and BAS scales indicate greater levels of inhibition or activation, respectively.

Adult self-report (ASR; Achenbach, 1991). The ASR is a 123-item self-report scale that includes items relating to emotional and behavioral functioning. For each item, emerging adult participants rated themselves on a scale of 0 = not true, 1 = somewhat or sometimes true, or 2 = very true or often true. The ASR is widely used, has strong psychometric properties (Achenbach & Rescorla, 2003). Raw scores for Internalizing and Externalizing symptomatology were used in the current study (higher scores represented more severe symptoms). The raw score for Interpersonal Adaptive Functioning was also evaluated as an outcome (higher scores represented more adaptive interpersonal functioning).

Diagnostic interview schedule for DSM-IV (DIS-IV; Robins et al., 1995). Alcohol use disorder symptomatology was assessed using the DIS-IV. The DIS-IV is a structured clinical interview, based on the DSM-IV, which provides clinical psychiatric diagnoses and symptom counts. For the present study, we used the diagnostic symptom count of alcohol use disorder. The symptom count ranged from 0–4, with 17.5% of the sample experiencing at least one symptom.

### Analytic plan

Childhood cortisol/DHEA profiles from Wave 1 were identified in the original, larger sample ( $N = 1,138$ ; R03HD103779, see Handley et al., 2023 for details). Handley et al. (2023) utilized seven indices of diurnal cortisol and DHEA (AM cortisol, cortisol AUC, cortisol slope, AM DHEA, DHEA AUC, DHEA slope, and cortisol/DHEA ratio) in the latent profile analysis. Results supported a four-class solution: Class 1 (60.0%) “Low Cortisol/Low DHEA” was characterized by low cortisol AM, AUC, and diurnal scores, as well as slightly low DHEA AM, AUC, and diurnal scores. The cortisol/DHEA ratio was also approximately average within this class. Class 2 (11.7%) “High Cortisol/Low DHEA” was characterized by high levels of cortisol AM, AUC, and diurnal levels, average-to-low DHEA AM, AUC, and diurnal scores, and a high cortisol/DHEA ratio. Class 3 (7.4%) “High Cortisol/High DHEA” was characterized by very high cortisol AM, AUC, and diurnal scores, high DHEA AM, AUC, and diurnal scores, and an average cortisol/DHEA ratio. Finally, Class 4 (17.4%) “Average Cortisol/High DHEA” was characterized by average cortisol AM, AUC, and diurnal scores, high DHEA AM, and AUC scores, average DHEA diurnal scores, and a low cortisol/DHEA ratio. Given the importance of applying person-centered analyses to large, diverse samples (Bray et al., 2015), individuals were classified to profiles from the original study (Handley et al., 2023) and profiles were retained for analysis within the current longitudinal follow-up study.

To examine the associations between established childhood cortisol and DHEA regulation profiles with emerging adult outcomes at W2, we conducted a series of analysis of covariance (ANCOVAs), controlling for possible confounding variables including maltreatment status, sex and age at wave 2. A series of seven models were estimated, one for each outcome of interest (i.e., four behavioral inhibition and activation system variables; adaptive interpersonal skills; and internalizing and externalizing symptomatology). We then investigated contrasts among significant results using a Tukey correction. We modeled number of alcohol use disorder symptoms as a count variable and determined the association between childhood cortisol and DHEA regulation profiles with alcohol use disorder with a Poisson (general linear model) regression. Because maltreatment exposure was found to predict increased odds of membership in Class 2 (*High cortisol/Low DHEA*; Handley et al., 2023), this class was selected as the reference category for the Poisson regression. Consistent with ANCOVA models, maltreatment, sex, and age at wave 2 were included as control variables.

## Results

### Descriptive statistics and correlations

See Table 1 for descriptive statistics and correlations between study variables. Results indicated higher levels of emerging adult externalizing symptoms ( $r = .11$ ,  $p < .05$ ) and lower levels of adaptive interpersonal behavior among individuals who experienced maltreatment in childhood ( $r = -.15$ ,  $p < .01$ ).

### Latent classes of cortisol and DHEA in current sample

Given attrition over time from childhood to emerging adulthood, prevalence rates in each cortisol and DHEA class (from Handley et al., 2023) shifted slightly such that for the present sample, there were 55.7% ( $n = 238$ ) in the *Low Cortisol and Low DHEA* class, 13.8% ( $n = 59$ ) in the *High Cortisol and Low DHEA* class; 9.8%

**Table 1.** Correlations and descriptive statistics

|                        | 1      | 2      | 3     | 4      | 5      | 6     | 7      | 8       | 9      | 10     | 11  |
|------------------------|--------|--------|-------|--------|--------|-------|--------|---------|--------|--------|-----|
| 1. Maltreatment Status | 1      |        |       |        |        |       |        |         |        |        |     |
| 2. Sex                 | .01    | 1      |       |        |        |       |        |         |        |        |     |
| 3. W2 Age              | .02    | -.06   | 1     |        |        |       |        |         |        |        |     |
| 4. BIS                 | -.06   | .33*** | -.04  | 1      |        |       |        |         |        |        |     |
| 5. BAS-Drive           | .02    | -.14** | .08   | .00    | 1      |       |        |         |        |        |     |
| 6. BAS-Reward Resp.    | -.05   | .04    | .14** | .29*** | .42*** | 1     |        |         |        |        |     |
| 7. BAS-Fun Seeking     | -.04   | -.19** | .09   | .12*   | .48*** | .44** | 1      |         |        |        |     |
| 8. ASR-Interpersonal   | -.15** | -.09   | -.11* | -.10   | .06    | -.03  | .11*   | 1       |        |        |     |
| 9. ASR-Internalizing   | .09    | .19*** | .01   | .32*** | .03    | -.01  | .06    | -.27*** | 1      |        |     |
| 10. ASR-Externalizing  | .11*   | .04    | .03   | .13*   | .19*** | .04   | .25*** | -.06    | .68*** | 1      |     |
| 11. AUD Symptoms       | .04    | -.12*  | .14*  | -.03   | .10    | .09   | .18*** | .04     | .06    | .24*** | 1   |
| <i>N</i>               | 686    | 686    | 427   | 404    | 404    | 404   | 404    | 405     | 405    | 405    | 405 |
| <i>Mean</i>            | –      | –      | 19.67 | 2.62   | 2.82   | 3.51  | 2.99   | 48.23   | 54.76  | 55.56  | .29 |
| <i>SD</i>              | –      | –      | 1.16  | .48    | .64    | .43   | .57    | 10.08   | 11.50  | 10.15  | .72 |
| %                      | 50.7   | 48.3   | –     | –      | –      | –     | –      | –       | –      | –      | –   |

Note. W2 = wave 2. BIS = Behavioral Inhibition System; BAS = Behavioral Activation System; ASR = Achenbach Self-Report; ASR Interpersonal = Adaptive Interpersonal Scale for Friends; AUD = Alcohol Use Disorder. Maltreatment is coded 0 = non-maltreated, 1 = maltreated and sex is coded as 1 = male and 2 = female. Higher scores on the BIS indicate higher inhibition whereas higher scores on the BAS indicate higher activation responses. Higher scores on the ASR interpersonal scale indicates better adaptation whereas higher scores on the ASR internalizing and externalizing scales indicate more symptomatology. \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

**Table 2.** Childhood cortisol/DHEA classes predicting emerging adult outcomes

| Outcomes             | Predictors              |                       |                       |                           |                       | Sig. Contrasts   | Covariates       |                  |                  |
|----------------------|-------------------------|-----------------------|-----------------------|---------------------------|-----------------------|------------------|------------------|------------------|------------------|
|                      | <i>F</i>                | Class 1 <i>M (SE)</i> | Class 2 <i>M (SE)</i> | Class 3 <i>M (SE)</i>     | Class 4 <i>M (SE)</i> |                  | Mal ( <i>F</i> ) | Sex ( <i>F</i> ) | Age ( <i>F</i> ) |
| BIS                  | 7.09**                  | 2.60 (.03)            | 2.48 (.06)            | 2.71 (.07)                | 2.73 (.05)            | 4 > 2*           | 2.00             | 39.34***         | 1.64             |
| BAS-Drive            | 1.25                    | 2.86 (.04)            | 2.83 (.09)            | 2.77 (.10)                | 2.72 (.07)            | n/a              | 0.19             | 6.63*            | 3.27             |
| BAS-Reward           | 0.28                    | 3.52 (.03)            | 3.51 (.06)            | 3.44 (.07)                | 3.50 (.05)            | n/a              | 0.85             | 0.81             | 9.58**           |
| BAS-Fun Seeking      | 0.79                    | 3.01 (.04)            | 2.98 (.08)            | 2.87 (.09)                | 2.98 (.06)            | n/a              | 0.63             | 14.47***         | 3.45             |
| ASR-Interpersonal    | 1.84                    | 8.90 (.18)            | 8.98 (.37)            | 9.05 (.43)                | 8.37 (.31)            | n/a              | 8.66**           | 2.07             | 4.40             |
| ASR-Internalizing    | 0.92                    | 16.20 (.75)           | 14.95 (1.52)          | 16.51 (1.78)              | 16.29 (1.29)          | n/a              | 3.18             | 12.72***         | 0.04             |
| ASR-Externalizing    | 0.31                    | 14.75 (.63)           | 15.75 (1.28)          | 13.39 (1.50)              | 14.45 (1.08)          | n/a              | 5.10*            | 0.64             | 0.79             |
| Alcohol use disorder | Predictors <sup>1</sup> |                       |                       |                           | Covariates            |                  |                  |                  |                  |
|                      | Class 1 ( <i>Z</i> )    | Class 3 ( <i>Z</i> )  | Class 4 ( <i>Z</i> )  | Maltreatment ( <i>Z</i> ) | Sex ( <i>Z</i> )      | Age ( <i>Z</i> ) |                  |                  |                  |
|                      | 2.13*                   | 1.04                  | 1.43                  | 1.20                      | -3.13**               | 3.12**           |                  |                  |                  |

Note. BIS = Behavioral Inhibition System; BAS = Behavioral Activation System; ASR = Achenbach Self-Report; Mal = Maltreatment status (coded 0 = non-maltreated, 1 = maltreated). Sex is coded as 1 = male and 2 = female. Alcohol use disorder refers to number of alcohol use disorder symptoms. Categories compared to Class 2, high cortisol/low DHEA. Class 1 is low cortisol/low DHEA; Class 3 is high cortisol/high DHEA; and Class 4 is average cortisol/high DHEA. \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

( $n = 42$ ) in the *High Cortisol and High DHEA* class, and 17.4% ( $n = 81$ ) in the *Average Cortisol and High DHEA* class.

### Associations between cortisol/DHEA classes and emerging adult outcomes

See Table 2 for results from the ANCOVAs and Poisson regression testing the associations between childhood cortisol and DHEA regulation profiles with emerging adult outcomes, controlling for maltreatment status, sex, and age at wave 2. Results indicated that individuals who experienced maltreatment in childhood reported lower interpersonal competence ( $M = 8.42$ ,  $SE = .21$ ) and higher externalizing symptoms ( $M = 15.63$ ,  $SE = .72$ ) in emerging

adulthood compared to individuals without maltreatment exposure (respectively:  $M = 9.22$ ,  $SE = .22$ ;  $M = 13.53$ ,  $SE = .76$ ). Moreover, men reported lower inhibition ( $M = 2.49$ ,  $SE = .04$ ), higher drive ( $M = 2.87$ ,  $SE = .05$ ), higher fun seeking ( $M = 3.06$ ,  $SE = .05$ ), and lower internalizing symptoms ( $M = 13.93$ ,  $SE = .92$ ) than women (inhibition:  $M = 2.77$ ,  $SE = .04$ ; drive:  $M = 2.72$ ,  $SE = .05$ ; fun-seeking:  $M = 2.86$ ,  $SE = .04$ ; internalizing:  $M = 18.05$ ,  $SE = .87$ ). Age at W2 was associated with reward responsiveness, such that older participants exhibited more reward responsiveness.

There was a significant association between childhood cortisol and DHEA profiles with the behavioral inhibition system,  $F(3, 394) = 7.09$ ,  $p < .001$ . Contrasts with Tukey correction for alpha inflation indicated that Class 4 (*Average Cortisol/High*

DHEA) exhibited higher levels of behavioral inhibition ( $M = 2.73$ ,  $SD = .41$ ) compared to Class 2 (*High Cortisol/Low DHEA*,  $M = 2.48$ ,  $SD = .44$ ),  $p = .02$ , controlling for child maltreatment, sex, and W2 age. There were no other significant associations between cortisol and DHEA regulation profiles with behavioral activation system variables, interpersonal adaptation, nor internalizing and externalizing symptomatology.

Results from the Poisson regression revealed that men and older participants endorsed a greater number of alcohol use disorder symptoms. Results also indicated a significant difference across cortisol/DHEA groups on alcohol use disorder symptoms. Specifically, compared with the High Cortisol/Low DHEA class (Class 2), Class 1 (Low Cortisol/Low DHEA) exhibited higher levels of alcohol use disorder symptomatology,  $IRR = .76$ ,  $z = 2.13$ ,  $p < .05$ .

## Discussion

The current empirical study utilized latent profiles of childhood neuroendocrine regulation (established in the Handley et al., 2023 study) to examine prospective links with emerging adult adaptive and maladaptive functioning across multiple developmental domains in a sample of individuals with and without childhood maltreatment exposure. Results indicated that person-centered profiles of neuroendocrine functioning evidenced in childhood prospectively predicted behavioral inhibition and alcohol use disorder in emerging adulthood. Specifically, findings highlighted that children with a diurnal pattern of neuroendocrine functioning marked by high cortisol and low DHEA experienced fewer symptoms of alcohol use disorder and less behavioral inhibition in emerging adulthood.

Emerging adulthood is a developmental period marked by a normative escalation in drinking alcohol and peak rates of alcohol use disorder (Chassin et al., 2016). Compared to those children who exhibited a more commonly occurring neuroendocrine pattern characterized by lower cortisol coupled with lower DHEA, children with the high cortisol/low DHEA pattern evidenced fewer alcohol use disorder symptoms in emerging adulthood. Notably, the majority of participants in this study demonstrated the low cortisol/low DHEA pattern in childhood (55.7%), as opposed to only 13.8% who evidenced the high cortisol/low DHEA pattern. Thus, these results suggest that a relatively less common childhood neuroendocrine pattern marked by high cortisol with low DHEA may represent a biomarker of resilience and adaptation during emerging adulthood.

In addition to the prediction of alcohol use problems later in development, the childhood neuroendocrine latent profiles also predicted behavioral inhibition during emerging adulthood. Results again highlighted that the childhood high cortisol/low DHEA pattern was associated with potentially more internal resources and greater adaptation in emerging adulthood. Specifically, children with this less common pattern of cortisol/DHEA imbalance were less behaviorally inhibited in emerging adulthood than those with the average cortisol/high DHEA pattern. It is notable that children with the average cortisol/high DHEA pattern were viewed as having more internalizing symptoms than children with other neuroendocrine profiles in childhood (Handley et al., 2023). Although a childhood pattern of average cortisol/high DHEA was not prospectively linked with internalizing symptoms in emerging adulthood in the current study, it's noteworthy that it was associated with higher levels of behavioral inhibition. Prior research linking behavioral inhibition and cortisol has been mixed (see Fox et al., 2005), and we advance

this work by showing the utility of person-centered methods to derive diurnal cortisol and DHEA patterns and their differential associations with inhibition in emerging adulthood.

It is important to understand these longitudinal findings within the scope of prior cross-sectional results with the same sample. Specifically, in Handley et al. (2023), it was documented that those children with the high cortisol/low DHEA imbalance pattern were also more likely to be perceived by both their peers and adults as interpersonally skilled. We interpreted this pattern of somewhat rare childhood diurnal cortisol and DHEA regulation as a potential biomarker of positive adaptation or a hidden talent (Ellis et al., 2022), given that children with this latent physiological pattern were also more likely to have experienced chronic maltreatment, compared to those in the high cortisol/high DHEA class. The current findings further bolster this interpretation, suggesting that in childhood, high cortisol production may offer an advantage by facilitating an adaptive effort to cope with anticipated social stress which, when paired with lower DHEA, may facilitate easier interactions in relationships. Positive social interactions in childhood may snowball into additional forms of resilience and positive adaptation in emerging adulthood, such as less problematic alcohol use and lower behavioral inhibition, as evidenced herein. Thus, high cortisol paired with low DHEA in childhood may characterize a high internal resource group.

Taken together, the results of the current empirical study provide preliminary evidence that a latent profile of high diurnal cortisol paired with low diurnal DHEA in childhood may be a biomarker of positive regulation of behavior and engagement in goal-directed behavior in emerging adulthood. These findings are noteworthy because they illustrate the advantage of person-centered data analytic methods for unpacking heterogeneity in childhood physiology to predict differential adaptation later in development. There are limitations worth noting, however. For instance, puberty is an incredibly salient sensitive period in development and there is evidence that it represents a recalibration period for the HPA axis (Gunnar, 2021). Given that our prospective design spanned, on average, ages 11 through 20, puberty and recalibration were likely influential in our findings. Unfortunately, pubertal developmental was not assessed in the study, nor was cortisol and DHEA reassessed in emerging adulthood. Future work guided by latent transition analysis (a person-centered method that estimates the probabilities of transitions in latent class membership over time; see Collins and Lanza, 2009 for full explanation of this method) may be useful in delineating how latent patterns of neuroendocrine functioning may shift over time.

We argued herein that person-centered data analytic methods represent a critical tool for developmental psychopathology. As with all statistical methods, careful consideration of how to specify and interpret models is vitally important to the appropriate application of person-centered approaches, and resources are available to help guide researchers as they apply these models to their research questions (e.g., Collins & Lanza, 2009; Lanza & Cooper, 2016; Nylund-Gibson & Choi, 2018). Despite limitations and challenges inherent to these analytic strategies (e.g., replication, generalizability, careful characterization of latent classes), person-centered approaches hold promise for the future of the field of developmental psychopathology. Guided by the developmental psychopathology framework, researchers can learn, incorporate, and improve upon existing research tools and analytic strategies, such as person-centered approaches, in the effort to better approximate the complex heterogeneity of clinical and developmental phenomena across the lifespan.



We included this empirical study within our commentary on the usefulness of person-centered methods for advancing the future of the field of developmental psychopathology for several reasons. First, given Dante Cicchetti's prominence within the field, and his major contributions to our understanding of the associations between child maltreatment exposure, neuroendocrine functioning, and the development of psychopathology and resilience, we chose this specific topic to honor his incredible legacy. Second, the design of the current study is noteworthy. This prospective investigation, which spanned approximately ten years, included an impoverished sample enriched for maltreatment exposure. During pre-adolescence, prior to engagement in substance use, children participated in a summer research camp, a methodology that enhanced engagement with children and families in the community. Participants were then reassessed in emerging adulthood, a developmentally salient time period for substance use disorder. Both data collection waves were marked by rich multimethod multiple levels of analysis assessments. As an original multiple principal investigator of the study, the methods and design showcase Dante Cicchetti's innovation, creativity, and wisdom regarding empirical tests of developmental psychopathology theory. Third, this empirical example touches on key principles of developmental psychopathology that have been pioneered by Dante Cicchetti; namely, the intersection of typical and atypical development, the criticality of studying multiple levels of analysis, multifinality in developmental processes, and resilience. Finally, we view person-centered methods as particularly useful for (1) unpacking variability within biological systems; (2) representing multiple levels of analysis holistically, and (3) differentiating adaptation from maladaptation following adversity exposure.

In conclusion, in this paper we asserted that person-centered data analytic methods are particularly well-suited to the complexities of developmental psychopathology. We highlighted the utility of these methods for addressing central principles of the field, all of which were advanced by Dante Cicchetti, and we illustrated the value of person-centered methods with a brief empirical example. The future of developmental psychopathology will undoubtedly be marked by highly complex, multimethod, multidisciplinary integrative research; we view person-centered methods as a critical tool for holistically unpacking this complexity. In Dante Cicchetti's own words, "The sophisticated and comprehensive portrayals of adaptation and maladaptation that ensue will serve not only to advance scientific understanding, but also to inform efforts to prevent and ameliorate psychopathology" (Cicchetti & Valentino, 2007).

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