Triarchic Neurobehavioral Correlates of Psychopathology in Young Children: Evidence from the Healthy Brain Network Initiative

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To cite this article: Isabella M. Palumbo, Christopher J. Patrick & Robert D. Latzman (2020): Triarchic Neurobehavioral Correlates of Psychopathology in Young Children: Evidence from the Healthy Brain Network Initiative, Journal of Personality Assessment, DOI: 10.1080/00223891.2020.1814311

To link to this article: https://doi.org/10.1080/00223891.2020.1814311

Published online: 23 Sep 2020.
Mental health researchers have increasingly recognized that neurobiological vulnerability and early temperament in childhood are important risk factors for the emergence of psychopathology in later years. Various models have been proposed for the pathogenesis and maintenance of psychopathology in childhood, focusing on biological (e.g., genetic, neurophysiological) factors and their relations with problem-related psychological processes (e.g., approach/avoidance, reward responsiveness, anxiety; Vasey & Dadds, 2001; depression, Goodyer, 2001; ADHD, Nigg, Goldsmith, & Sachek, 2004; conduct problems; Frick & Morris, 2004; Reid, Patterson, & Snyder, 2002). From the standpoint of such models, temperament-related constructs with neurobiological, as well as psychological referents, are particularly useful for explicating developmental risk factors for psychopathology in early childhood (for discussion of this, see Perkins et al., 2020). For example, there is evidence that neurobehavioral traits index liability for psychopathology more effectively than conventional trait dimensions (e.g., Joyner et al., 2020; Venables et al., 2017). Despite the growing interest in understanding mental health problems and risk for psychopathology in neurobehavioral terms, persisting challenges have hampered efforts in this direction—including (a) the use of disparate approaches to conceptualizing and measuring risk factors in childhood, (b) dysjunction in assessments of risk factors at earlier versus later ages (e.g., differing measures, differing informants), and (c) basic measurement issues in relating biological and behavioral indicators of risk factors to report-based assessments of clinical problems. A new approach to conceptualizing and studying risk factors, the triarchic neurobehavioral trait model (Patrick, Fowles, & Krueger, 2009), holds promise in this regard. Indeed, although the triarchic traits were originally formulated to facilitate understanding of psychopathic personality in neurobehavioral terms, their conceptual resemblance to basic dimensions of temperament has made them useful for understanding other forms of psychopathology (e.g., Patrick et al., 2013).

The triarchic model is compatible with established temperament-oriented models of psychopathology but contains distinct features for addressing key methodological challenges. One is its focus on psychopathology-related traits with direct relevance to neural systems and replicable neural and behavioral correlates (e.g., Palumbo et al., in press; Venables et al., 2017, 2018; Yancey, Venables, & Patrick, 2016). Another is its capacity to serve a data-harmonization function, insofar as the model’s trait constructs can be effectively operationalized using various item sets (Patrick & Drislane, 2015). Finally, given the compatibility with traditional temperament models, the triarchic model serves to
link neurobehavioral temperament-trait risk factors and psychopathology within a developmental framework.

**The triarchic model**

Temperament has been defined as "biologically rooted individual differences in behavioral tendencies that are present in early life and are relatively stable across various kinds of situations and over the course of time" (Bates, 1987, p. 1101). This conceptualization allows for the integration of dimensional trait characteristics and associated neurobiological processes in developmental expressions of psychopathology. Proposed structural models of temperament in children consistently refer to three temperament dimensions representing fear/fearlessness, effortful control, and affiliation/antagonism (Mervielde & de Pauw, 2012). Operating from an integrative neurobehavioral perspective, these dimensions of temperament have been discussed in relation to distinct neurobiological processes and affiliated classes of behavior, and extremes along these temperament trait dimensions have been posited as risk factors for psychopathology (Clark, 2005; Muris & Ollendick, 2005; Nigg, 2006).

In line with this notion, the triarchic model focuses on developmentally meaningful personality constructs compatible with well-established temperament models (Patrick et al., 2009). As noted above, though originally developed to quantify trait dimensions of psychopathy, the triarchic model conceptualizes trait constructs of *boldness* (low vs. high threat sensitivity), *meanness* (low vs. high affiliative capacity), and *disinhibition* (low vs. high inhibitory control) with reference to existing literature on development, neurobiology, personality, and psychopathology. These three traits show some phenotypic overlap (in particular, measures of disinhibition and meanness tend to correlate moderately) but are theorized to involve different neurobehavioral systems/processes, and relate in distinct ways to clinical problems of particular types – ranging from psychopathy (Patrick & Drislane, 2015), to antagonistic expressions of externalizing (Patrick et al., 2013; Venables et al., 2017), to internalizing problems (e.g., Anderson et al., 2014; Latzman et al., 2019, 2019, 2020; Venables et al., 2017). Thus, given its developmental underpinnings and established links to the adult psychopathology literature, the triarchic model has potential to contribute to understanding the etiology and trajectory of developmental risk for psychopathology.

**Boldness**

An extensive literature documents stable individual differences in children’s behavioral proclivities to react to and avoid situations involving uncertainty or threat (e.g., Fox et al., 2005; Kagan, 1989; Muris et al., 2005). Whereas some children are relatively fearless and quick to approach and engage with unfamiliar surroundings (i.e., fearlessness/resiliency; Kagan, 1994; Hane, 2008; Rothbart, 2012) and people (i.e., sociability/social dominance; Buss, 1991; Hawley, 1999; Rothbart et al., 2001; Dyson et al., 2012), other children find unfamiliar situations aversive and anxiety-provoking and are prone to withdraw from such situations. These two temperament profiles (i.e., fearless and fearful) are apparent in toddlerhood, show evidence of heritability, and are associated with distinct physiological response patterns (Fox et al., 2005; Kagan, 1989) and clinical vulnerabilities (fearfulness with internalizing problems [Biederman et al., 2001; Kagan, 1989], and fearlessness with externalizing problems [Biederman et al., 2001; Shaw et al., 2003]). In line with this literature, the construct of boldness encompasses fearless venturesomeness, emotional stability, and social dominance/efficacy (Lilienfeld, Watts, Smith, & Latzman, 2018) and is theorized to reflect individual differences in the sensitivity of the brain’s defensive motivational system (Patrick, 1994; Benning, Patrick, & Iacono, 2005). In support of this research has shown that adolescents and adults high in boldness show reduced physiological defensive reactivity (e.g., lack of enhanced startle reactivity during exposure to threat cues; Benning, Patrick, & Iacono, 2005; Esteller, Poy, & Moltó, 2016; Vaidyanathan, Patrick, & Bernat, 2009).

**Meanness**

The second triarchic dimension, meanness (also known as callous-unemotionality; Frick, 2004; Frick et al., 2014), entails an inability or disinclination to form close personal relationships, callous disregard for others, and impaired emotional sensitivity and responsiveness. Meanness in youth relates to antisocial behavior problems (Frick & White, 2008; Kimonis et al., 2006; Mervielde et al., 2005; Nigg, 2006) and different forms of aggression (Frick et al., 2014; Dadds & Rhodes, 2008), especially when accompanied by disinhibition/low effortful control (Eisenberg et al., 2003; Kochanska & Knaack, 2003; White, Jarrett, & Ollendick, 2012). While its association with internalizing psychopathology is less well-established (Rothbart, 2007; Mervielde et al., 2005, 2006), some studies have shown meanness/low affiliativeness to be positively associated with internalizing symptoms in youth and adulthood (e.g., Barker & Salekin, 2012; Cusi et al., 2011; Essau et al., 2006) and with internalizing-related temperament traits (e.g., Berg et al., 2013; Latzman et al., 2013). By contrast, low meanness may protect against maladaptive outcomes, as a function of positive effects of the social support that accrues from empathic concern and connectedness with others (DeVries, Glasper, & Detillion, 2003; La Greca & Harrison, 2005). Neural and behavioral correlates of meanness include reduced brain reactivity to interpersonal distress cues (e.g., fearful facial expressions; Brislin et al., 2018; Marsh & Blair, 2008) and heightened tolerance for pain (e.g., Brislin et al., 2016).

**Disinhibition**

The triarchic construct of disinhibition reflects the concept of low effortful control from the temperament literature and encompasses attributes of impulsiveness, difficulty in delaying gratification, low frustration tolerance, and poor emotion regulation (Patrick et al., 2009). Disinhibition contributes in particular to externalizing problems (Krueger et al., 1996; Caspi, Henry, McGee, Moffitt, & Silva, 1995).
and to a lesser degree internalizing problems (Calkins & Fox, 2002; Venables et al., 2017), given its association with negative emotionality. Whereas children exhibiting disinhibition (i.e., low effortful control) are prone to combative or avoidant behavior and difficulties in coping with negative feelings, children low in disinhibition are effective at regulating negative emotions through the use of strategic, flexible, and effective coping strategies that operate as protective factors (Lengua & Long, 2002; Salmon & Pereira, 2002). Disinhibition is thought to reflect individual differences in frontal-executive functioning and has been related to a neural network including the prefrontal cortex, anterior cingulate, and basal ganglia (Rothbart, Ellis, Rosario Rueda, & Posner, 2003). Poor performance on executive-function tasks and neural network dysfunction has also been implicated in externalizing disorders (Raine, 2002; Woltering et al., 2016) as well as internalizing disorders in youth (Halari, et al., 2009; Vijayakumar et al., 2014; Woltering et al., 2016). Neural and behavioral indicators of disinhibition in youth and adulthood include reduced oddball-P3 brain response (e.g., Patrick et al., 2013; Venables et al., 2018) and impaired performance on cognitive control tasks (Venables et al., 2018; Young et al., 2009).

In sum, a neurobehavioral temperament-trait framework holds promise for advancing understanding of the etiology and continuity of internalizing and externalizing psychopathology. One such framework, the triarchic trait model (Patrick, Fowles, & Krueger, 2009; Patrick & Drislane, 2015), places emphasis on developmental phenotypic constructs (i.e., fear/fearlessness, effortful control, affiliation), with clear neurobiological and psychological referents (Palumbo et al., in press; Patrick et al., 2013; Venables et al., 2017, 2018; Yancey et al., 2016), as a means to “upwardly extend” temperament constructs from childhood to adulthood.

Assessment of triarchic trait constructs

The self-report Triarchic Psychopathy Measure (TriPM; Patrick, 2010) was created specifically to index the traits of the triarchic model, and strong validity evidence has been reported (Patrick & Drislane, 2015). Empirical studies have demonstrated that the triarchic traits can be also effectively quantified using items from other inventories of normal and abnormal personality (e.g., Brislin et al., 2019; Hall et al., 2014). Studies of this type have used a construct-rating and empirical item-analysis approach (see Hall et al., 2014) to select candidate items from one or more source inventories and refine them into effective triarchic scale measures. This practice provides a means to capitalize on rich existing datasets to advance understanding of how trait liabilities contribute to the development and maintenance of clinical problems (see Brislin et al., 2018).

The majority of research to date examining relations of the triarchic trait constructs with psychopathology have used adult samples. However, some recent work has provided evidence for the developmental continuity of triarchic traits (Green et al., 2020; Kyraniades et al., 2017; Sica et al., 2019) indicating the ability to downwardly extend the operationalization of triarchic trait dimensions to young children suggesting the ability to downwardly extend the operationalization of triarchic trait dimensions to young children. However, there is a clear need for further research evaluating whether the triarchic traits can be effectively assessed in childhood through informant report and how they relate to clinical problems when assessed this way. Building on recent efforts with adults (e.g., Brislin et al., 2015; Drislane et al., 2018; Hall et al., 2014) and more recently with adolescents (Brislin et al., 2019), the current study was undertaken to examine the extent to which associations reported for the triarchic traits with externalizing and internalizing psychopathology in adult samples replicate within young childhood. In service of this, we evaluated the effectiveness of items administered in the context of the Child Mind Institute’s Healthy Brain Network (Alexander et al., 2017) initiative – a community study undertaken to generate a large publicly available multimodal database – for indexing triarchic trait constructs in a sample of 5-to-10-year-old children.

Present study

The major aim of the current study was to investigate the unique contributions of the triarchic model traits, operationalized using data for 5-10-year-old children tested in the Health Brain Network (HBN) study (Alexander et al., 2017), to internalizing and externalizing psychopathology within this sample. More specifically, the current work was undertaken to a) develop scale operationalizations of the triarchic constructs of boldness, meanness, and disinhibition in one cohort of HBN study participants using items from parent-report inventories in an effort to extend triarchic model constructs to children, b) evaluate the psychometric properties of the resultant HBN-based triarchic (HBN-Tri) scales in two independent samples (i.e., a second cohort of child-aged HBN participants, and a separate sample of parents reporting on their children via the online MTurk platform), c) examine associations of the three triarchic traits with measures of internalizing and externalizing psychopathology. In addition, exploratory analyses were conducted to test for interactions among the triarchic scales in relation to psychopathology dimensions.

Following procedures used to develop triarchic scale measures from other item sets (e.g., Brislin et al., 2019; Hall et al., 2014), candidate items for each trait scale were identified using a consensus rating approach and then refined through iterative internal psychometric analyses. Based on findings from previous triarchic scale-development efforts, we predicted that: (1) scales developed in HBN cohort 1 would exhibit good psychometric properties in the two cross-validation samples (HBN cohort 2, MTurk adult sample). In addition, we used parent-report and interview-based assessments of psychopathology for the full HBN sample to test the following hypotheses: (2) boldness and disinhibition would evidence negative and positive associations, respectively, with internalizing problems, whereas meanness would be largely unrelated to problems of this type (Latzman et al., 2019, 2020), and (3) meanness and disinhibition would exhibit strong positive associations with externalizing problems, whereas boldness would relate less robustly to such problems (Patrick & Drislane, 2015). Finally, given growing interest in
examining interactive effects for the triarchic dimensions (e.g., Green et al., 2020; Latzman et al., 2019, 2020; Sellbom, 2015), exploratory analyses were conducted to test for possible interactions between the triarchic traits in the prediction of internalizing and externalizing problems.

Method

Participants

Scale development and initial psychometric evaluation of the scales were undertaken in the first cohort of 5-10-year-old children ('Release 1’ sample; n = 285; Mage = 8.1, SD = 1.6 years, 34.4% female) tested in the HBN consortium project (for more detail about this project, see Alexander et al., 2017), which included the collection of both parent-report and diagnostic interview data. The racial/ethnic composition was 49.4% White, 16.2% Black/African American, 13.8% Hispanic, and 20.6% Biracial or Other.

Following the development of the HBN-Tri scales in the Release 1 sample, parent-report and clinical interview data for a second HBN cohort ('Release 2’ sample; n = 519) were made available for research use. The mean age of participants in this sample (used for scale validation), 31.8% of whom were female, was 8.4 (SD = 1.4 years); the racial/ethnic composition was 49.3% White, 17.0% Black/African American, 10.5% Hispanic, and 23.2% Biracial or Other. Participants in both HBN samples were provided with study information through the HBN project, and children and parents provided written assent and consent, respectively.

The items of the final HBN-Tri scales were also administered to a third, non-HBN sample of parents using the Amazon Mechanical Turk (MTurk) platform. Parents comprising this sample reported on a child of theirs between the ages of 5-10 years (N = 261; Mage = 7.12, SD = 1.7 years; 49.4% female) The racial composition of the children rated by parents in this MTurk sample was 71.5% White, 9.2% Black/African American, 8.0% Asian, and 11.2% identifying as Biracial or Other. Procedures for collection of data for this sample were approved by the lead author’s university institutional review board and all participants provided electronic written consent. Given recent concerns regarding the validity of data collected via online platforms (for a review, see Hauser et al., 2018; Kennedy et al., 2018), a quality control evaluation was employed for the MTurk sample, specifically. Twelve individuals were excluded due to anomalous response patterns (i.e., ≥ 90% of items answered with the same response option [e.g., ‘Does not apply at all’, ‘Does not apply well’, ‘Applies fairly well’, ‘Applies very well’], resulting in a final analysis sample of 249 participants.

Measures

Triarchic scale development: Sources of candidate items for HBN-Tri scales

The initial pool of candidate items for developing scale measures of the triarchic model constructs (boldness, meanness, disinhibition) consisted of 259 conceptually-relevant items taken from six inventories administered to all parent participants in the HBN study (i.e., both Release 1 and Release 2 samples) – Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001), Affective Reactivity Index – Parent Report version (ARI; Stringaris et al., 2012), Inventory of Callous-Unemotional Traits – Parent Report (ICU; Frick, 2004), Screen for Child Anxiety Related Disorders – Parent Version (SCARED; Birmaher et al., 1999), Strengths and Difficulties Questionnaire – Parent Report (SDQ; Goodman, 1997), Social Responsiveness Scale (SRS; Constantino, 2005). Descriptions of these six inventories and pertinent citations are provided in the online Supplemental Materials document.

Relations of HBN-Tri scales with psychopathology measures.

The HBN study protocol included an interview-based measure of general psychopathology, the Kiddy Schedule for Affective Disorders and Schizophrenia (K-SADS; Kaufman et al., 1997), which was scored on the diagnostic consensus of both child and parent responses to open- and closed-ended questions (see Supplemental Materials for details). Specifically, a conservative approach was taken in which a symptom was considered if it was endorsed by either child or parent. A second psychopathology measure, the informant-rated CBCL, was administered to parents in the two HBN samples and completed also by parent raters in the MTurk sample. For the CBCL, scores on its two broad problem scales – ‘Internalizing’, reflecting the sum of scores for Anxious/Depressed, Withdrawn/Depressed, and Somatic Complaints syndrome scales, and ‘Externalizing’, reflecting the sum of scores Rule-Breaking Behavior and Aggressive Behavior scales – were computed using modified versions of the syndrome scales, omitting each item included in the final HBN-Tri scales (see Supplement for details). Consistent with recommendations for use of the CBCL (Achenbach & Rescorla, 2001), results for the Attention Problems scale are reported separately, alongside findings for the Internalizing and Externalizing problem scales. Cronbach’s alpha for the modified CBCL scale scores in the HBN development (Release 1, N = 255) and evaluation (Release 2; N = 519) samples, and in the MTurk sample (N = 261), were (respectively) as follows: Internalizing problems, .88, .85, and .90; Externalizing problems, .90, .90, and .93; Attention Problems, .84, .80, and .79.

For the K-SADS, which assesses for current and past episodes of internalizing and externalizing psychopathology in children and adolescents according to the criteria of the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 2000), validity data are reported for lifetime prevalence of eight specific diagnostic conditions across combined HBN samples (each scored 0 = absent, 1 = present at any point in lifetime; N = 481): social anxiety (n = 38), separation anxiety (n = 45), specific phobia (n = 63), major depressive disorder (MDD; n = 7), generalized anxiety disorder (GAD; n = 40), conduct disorder (n = 6), oppositional defiant disorder (ODD; n = 100), and attention deficit/hyperactivity disorder (ADHD; n = 271). In addition, an Internalizing composite was computed as the sum of present versus absent scores for the first 5 of these
conditions (yielding scores from 0 to 5), and an Externalizing composite was computed as the sum of scores for ODD and conduct disorder (yielding values from 0 to 2). As with the CBCL, results for the diagnosis of ADHD are reported separately, alongside results for the internalizing and externalizing composites.

Procedure

Scale construction in HBN release 1 sample

Questionnaires used as sources of items for the HBN-Tri scales were administered as part of the HBN project’s assessment protocol (see Alexander et al., 2017 for a detailed description). Scale development followed procedures used in previous studies to create scale measures from items of existing inventories (e.g., Hall et al., 2014; Brislin et al., 2019; see Supplemental Materials for a detailed description). In the development phase, candidate items from the ARI, CBCL, ICU, SCARED, SDQ, and SRS were selected for each triarchic scale based on ratings of construct relevance, employing definitions used in prior studies. Of note, the CBCL contains both trait-oriented items (e.g., pertaining to not feel guilty after behaving badly), as well as symptom-oriented items (e.g., pertaining to speaking about killing oneself). To ensure that the derived scales effectively captured dispositional liabilities of boldness, meanness, and disinhibition, only items of the CBCL that were reflective of traits were considered during the scale construction phase. To accommodate differences in response formats among the inventories, scores for individual items were standardized (i.e., z-score transformed) across participants before computing scale scores. Items selected for potential inclusion, consisting of those with the highest mean construct-relevance scores across raters, underwent refinement through analytic procedures used in previous studies (described further below, e.g., Hall et al., 2014; Brislin et al., 2019).

Evaluation of triarchic scale psychometric properties in HBN release 2 and MTurk samples

Following scale development in the HBN Release 1 sample, the psychometric properties of each final HBN-Triarchic scale were evaluated in the HBN Release 2 sample and the MTurk sample (i.e., alpha and omega reliability indices, intercorrelations among HBN-Tri scales).

Exploratory structural equation modeling

To further evaluate the internal, item-level structure of the scales developed in the Release 1 sample, an omnibus exploratory structural equation model (ESEM) of the HBN-Tri items was used to specify the triarchic dimensions using robust weighted least square (WLSMV) estimation; in the model, three factors were extracted and items were target-rotated to their respective factor (see Patrick et al., in press, for discussion of this analytic approach for explicating the structure of triarchic dimensions). Consistent with previous studies employing this approach (Somma et al., 2019; Latzman et al., 2019), theoretically- and empirically-meaningful correlations among item residuals were permitted to account for co-dependencies among items within each scale. Model goodness-of-fit was assessed using chi-square test of model fit ($\chi^2$), root mean square error of approximation (RMSEA), and comparative fit index (CFI). This ESEM model was specified and evaluated in both HBN samples as well as the MTurk sample.

Evaluation of scale relations with psychopathology

Predicted patterns of convergent and discriminant relations for the three HBN-Tri scales with psychopathology variables were examined within the combined (Release 1 + Release 2) HBN sample and the MTurk sample. To ensure there was no item overlap, abbreviated CBCL symptom scales were calculated excluding the items used to construct the HBN-Tri scales. Additionally, to evaluate the unique and shared contribution of each HBN-Tri scale to the prediction of psychopathology measures, regression analyses were conducted in which scores on the three HBN-Tri scales were included as concurrent predictors of each of the CBCL and KSADS psychopathology variables. A further set of exploratory regression analyses tested for possible interactions between pairs of HBN-Tri scales in predicting the psychopathology variables. The nature of any observed two-way interaction effect was characterized by plotting simple slopes reflecting the association of one triarchic scale with the target psychopathology variable at differing levels (M, 1 SD above the M, and 1 SD below the M) of the other triarchic scale (Aiken &
West, 1991), using an online computational tool (Preacher et al., 2006).

Results

HBN-Tri item selection

As described in greater detail in the Supplemental Materials, initial candidate items for each of the three triarchic constructs were identified based on level of agreement among raters resulting in 10 items for boldness, 14 for meanness, and 8 for disinhibition. Candidate items were dropped if they demonstrated poor psychometric properties in relation to other target scale items or reduced cross-correlations of the target scale with the other HBN-Tri scales. Consensus rating criteria were relaxed to allow for the addition of items that showed strong item-total correlations, increased internal consistency, and divergence with non-target triarchic scales. The final HBN Boldness scale contains 8 items (6 reverse-keyed), with Meanness containing 13 items (6 reverse-keyed) and Disinhibition 7 items (3 reverse-keyed; see Supplemental Table A).

Psychometric properties of final HBN-Tri scales in the three study samples

For concision and clarity, psychometric properties of the HBN-Tri scales within each of the three samples are provided in Table 1. Considering their brevity (7-13 items) and diversity of item content, the final HBN-Tri scales each evidenced good internal consistency (Cronbach’s alpha, omega, and average intra-item correlation) across all three samples. Further, bivariate correlations within the three samples revealed a moderate positive correlation between HBN Meanness and Disinhibition, and modest negative correlations for each of these two scales with HBN Boldness.

Structural modeling

As described above, all HBN-Tri items were jointly analyzed in a three-factor WLSMV ESEM model, which included residual correlations among particular items within each TriPM scale. Specifically, modification indices and item descriptors were reviewed and resulted in the following item pairs: for boldness, SRS 3 and SRS 11 (reflecting self-confidence); meanness, SDQ 1 and ICU 8 (concern about other’s feelings), CBCL 16 and ICU 4 (aggression, exploitation), CBCL 26 and ICU 18 (remorse for wrong-doing); disinhibition, CBCL 41 and SDQ 21 (impulsivity). Consistent with previous studies (e.g., Somma et al., 2019; Latzman et al., 2019), this three-factor model evidenced good fit to the data in the HBN Release 1 sample ($\chi^2$ [292] = 513.737, $p < .001$, RMSEA = .052, TLI = .888, CFI = .914), with items assigned a priori to each triarchic dimension largely loading on factors corresponding to Boldness, Meanness, and Disinhibition (see Supplemental Table B). Of note, one item assigned to the Meanness scale and one assigned to the Disinhibition scale showed cross-loadings onto the Disinhibition and Meanness factors, respectively. Specifically, CBCL item 16, reflecting aggression, loaded to a similar degree on Disinhibition, and ICU 23, reflecting uncaring, loaded to a similar degree on Meanness. Notably, fit indices also evidenced acceptable fit in the HBN Release 2 sample ($\chi^2$ [292] = 580.680, $p < .001$, RMSEA = .044, TLI = .892, CFI = .916) and the MTurk sample ($\chi^2$ [292] = 557.707, $p < .001$, RMSEA = .060, TLI = .852, CFI = .885) (see Table 2).

Associations with psychopathology measures²

Results from correlational and regression analyses examining associations between the three HBN-Tri scales and measures of psychopathology are presented in Tables 2 and 3. Data for the HBN Release 1 and Release 2 samples were combined for these analyses, resulting in a total N of 804; however, due to missing data for each of the psychopathology inventories and use of list-wise deletion in reported analyses, the validity coefficients for K-SADS and CBCL are based on sample sizes of 481 and 770, respectively. Bivariate and regression analyses were conducted to investigate HBN-Tri associations with K-SADS and CBCL composite scores (Table 4) and individual KSADS diagnoses (Table 5). A final set of analyses tested for interactions between the triarchic traits in predicting internalizing and externalizing psychopathology (Figures 1a-c).

CBCL

Notably, bivariate and multiple regression associations between psychopathology and HBN-Tri scales were highly consistent across the combined HBN and MTurk samples (see Table 2). Specifically, at the bivariate level, CBCL internalizing was associated to a moderate positive degree in each sample with both Disinhibition ($rs = .42$ and .44, respectively, $p < .001$) and Meanness ($rs = .36$ and .51, $p < .001$), and to a strong negative degree with HBN Boldness ($rs = -.60$ and -.53, $p < .001$). In multiple regression analyses including all HBN-Tri scales together as predictors of internalizing symptomatology, Boldness emerged as a significant unique predictor in both samples (HBN, $\beta = -.54$, $t = -20.0$, $p < .001$; MTurk, $\beta = -.40$, $t = -.769$, $p < .001$), along with Meanness (HBN, $\beta = .13$, $t = 3.95$, $p < .001$; MTurk, $\beta = .32$, $t = 4.70$, $p < .001$). Disinhibition emerged as a significant predictor of CBCL internalizing symptoms within the HBN sample, ($\beta = .24$, $t = 7.15$, $p < .001$), but not within the MTurk sample ($\beta = .11$, $t = 1.57$, $p = .12$).

At the bivariate level, CBCL externalizing showed strong positive associations with both Meanness and Disinhibition, in the combined HBN sample as well as the MTurk sample (rs for Meanness = .64 and .62, respectively, $p < .001$; rs for Disinhibition = .78 and .63, $p < .001$). By contrast, Boldness evidenced low-to-moderate negative associations

²Supplemental analyses were performed controlling for age and sex. Observed associations of triarchic traits with psychopathology variables remained the same in the two validation samples.
with externalizing in the two samples ($r = -0.27$ and $-0.33$, $p < .001$). In line with these bivariate associations, all three HBN-Tri scales emerged as significant predictors of CBCL externalizing within both samples when entered as concurrent predictors in regression analyses. Meanness and Disinhibition emerged as strong positive predictors (for HBN sample, $\beta$ = .25 and .61, respectively, $t_s = 9.45$ and 23.42, $p < .001$; for MTurk, $\beta$ = .33 and .37, $t_s = 5.21$ and 5.86, $p < .001$), whereas HBN Boldness evidenced a weak negative association in each sample (HBN, $\beta = -0.12$, $t = 0.56$, $p < .001$; MTurk, $\beta = -0.12$, $t = -2.41$, $p = .01$).

To remain consistent with the traditional structure of the CBCL (Achenbach & Rescorla, 2001), associations between HBN-Tri scales and CBCL attention problems were examined separately. HBN Meanness and Disinhibition evidenced moderate and strong bivariate associations, respectively, with attention problems in the HBN and MTurk samples (for Meanness = .30 and .44, respectively, $p < .01$; for Disinhibition = .52 and .59, $p < .01$), whereas correlations for Boldness were moderately negative ($r = -0.35$ and $-0.30$, $p < .01$). Notably, in regression analyses, only HBN Boldness and Disinhibition emerged as unique predictors in each sample (for Boldness = $-0.26$ and $-0.20$, $t = 8.79$ and $-2.48$, $p < .001$ and .02, respectively; for Disinhibition = .52 and .51, $t_s = 14.19$ and $7.31$, $p < .001$). Predictive relations for HBN Meanness in the regression

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**Table 2. Goodness-of-Fit Statistics for Weighted Least Squares Mean and Variance Adjusted Exploratory Structural Equation Models of HBN-Tri Items in Each Study Sample.**

<table>
<thead>
<tr>
<th></th>
<th>$\chi^2$(df)</th>
<th>CFI</th>
<th>RMSEA</th>
<th>90% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBN Release 1</td>
<td>513.737(292)</td>
<td>.914</td>
<td>.052</td>
<td>.044, .059**</td>
</tr>
<tr>
<td>HBN Release 2</td>
<td>580.680(292)</td>
<td>.916</td>
<td>.044</td>
<td>.036, .049**</td>
</tr>
<tr>
<td>MTurk</td>
<td>557.707(292)</td>
<td>.885</td>
<td>.060</td>
<td>.053, .068**</td>
</tr>
</tbody>
</table>

*Note. CFI = comparative fit index; RMSEA = root mean square error of approximation; CI = confidence interval for RMSEA; HBN Release 1 (N = 285), HBN Release 2 (N = 519), MTurk (N = 249). HBN = Healthy Brain Network; MTurk = Mechanical Turk sample.

* $p < .001.$

**Table 3. Bivariate and regression analyses among HBN-Tri scales and CBCL psychopathology within the combined HBN and MTurk samples.**

<table>
<thead>
<tr>
<th>CBCL Psychopathology</th>
<th>HBN Boldness ($r$ ($f$))</th>
<th>HBN Meanness ($r$ ($f$))</th>
<th>HBN Disinhibition ($r$ ($f$))</th>
<th>R / $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HBN</td>
<td>MTurk</td>
<td>HBN</td>
<td>MTurk</td>
</tr>
<tr>
<td>Internalizing</td>
<td>-60$^<em>$ (-54$^</em>$)</td>
<td>-55$^<em>$ (-40$^</em>$)</td>
<td>36$^<em>$ (13$^</em>$)</td>
<td>51$^<em>$ (32$^</em>$)</td>
</tr>
<tr>
<td>Externalizing</td>
<td>-27$^<em>$ (-12$^</em>$)</td>
<td>-33$^<em>$ (-12$^</em>$)</td>
<td>64$^<em>$ (35$^</em>$)</td>
<td>62$^<em>$ (33$^</em>$)</td>
</tr>
<tr>
<td>Attention Problems</td>
<td>-35$^<em>$ (-26$^</em>$)</td>
<td>-30$^<em>$ (-13$^</em>$)</td>
<td>30$^*$ (-06)</td>
<td>44$^*$ (05)</td>
</tr>
</tbody>
</table>

*Note. Combined HBN development and evaluation samples, N = 767; MTurk sample, N = 249. Regression analyses included all three HBN-Tri scales as predictors of each psychopathology-related variable. Range and mean (std. dev.) for CBCL psychopathology: Internalizing = 1.95, .29 (.26); Externalizing = 1.50, .30 (.26); Attention Problems = 2.00, .78 (.46). HBN = Healthy Brain Network; MTurk = Mechanical Turk sample; CBCL = Child Behavior Checklist.

+$p < .001.$

**Table 4. Bivariate and regression analyses among HBN-Tri scales and KSADS psychopathology within the combined HBN sample.**

<table>
<thead>
<tr>
<th>KSADS Psychopathology</th>
<th>HBN Boldness ($r$ ($f$))</th>
<th>HBN Meanness ($r$ ($f$))</th>
<th>HBN Disinhibition ($r$ ($f$))</th>
<th>R / $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HBN</td>
<td>MTurk</td>
<td>HBN</td>
<td>MTurk</td>
</tr>
<tr>
<td>Internalizing Composite</td>
<td>-44$^<em>$ (-44$^</em>$)</td>
<td>.04 (-07)</td>
<td>.10$^*$ (-07)</td>
<td>.45 / .20$^*$</td>
</tr>
<tr>
<td>Externalizing Composite</td>
<td>-09$^*$ (-09)</td>
<td>.46$^<em>$ (-26$^</em>$)</td>
<td>.49$^<em>$ (34$^</em>$)</td>
<td>.54 / .29$^*$</td>
</tr>
<tr>
<td>ADHD</td>
<td>-15$^<em>$ (-11$^</em>$)</td>
<td>.09$^<em>$ (-13$^</em>$)</td>
<td>.30$^<em>$ (35$^</em>$)</td>
<td>.33 / .11$^*$</td>
</tr>
</tbody>
</table>

*Note. Combined HBN development and evaluation samples, N = 481. Regressions analyses included all three HBN-Tri scales as predictors of each psychopathology-related variable. Mean and standard deviation for KSADS psychopathology: Internalizing Composite = 39 (.73); Externalizing Composite = 22 (.43); ADHD = 56 (.50). HBN = Healthy Brain Network; K-SADS = Kiddy Schedule for Affective Disorders and Schizophrenia.

+$p < .001.$

**Table 5. Bivariate correlations and regressions among HBN-Tri scales and individual KSADS diagnoses.**

<table>
<thead>
<tr>
<th>KSADS Diagnoses</th>
<th>HBN Boldness ($r$ ($f$))</th>
<th>HBN Meanness ($r$ ($f$))</th>
<th>HBN Disinhibition ($r$ ($f$))</th>
<th>R / $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation Anxiety Disorder</td>
<td>-35$^<em>$ (-35$^</em>$)</td>
<td>.03 (-03)</td>
<td>.05$^*$ (-01)</td>
<td>.35 / .12$^*$</td>
</tr>
<tr>
<td>Social Anxiety Disorder</td>
<td>-30$^<em>$ (-31$^</em>$)</td>
<td>-.01 (-02)</td>
<td>-.03 (-07)</td>
<td>.31 / .10$^*$</td>
</tr>
<tr>
<td>Specific Phobia</td>
<td>-19$^<em>$ (-18$^</em>$)</td>
<td>.01 (-08)</td>
<td>.09$^<em>$ (11$^</em>$)</td>
<td>.21 / .05$^*$</td>
</tr>
<tr>
<td>Major Depressive Disorder</td>
<td>-11$^<em>$ (-09$^</em>$)</td>
<td>.12$^<em>$ (09$^</em>$)</td>
<td>.09$^<em>$ (02$^</em>$)</td>
<td>.15 / .02$^*$</td>
</tr>
<tr>
<td>Generalized Anxiety Disorder</td>
<td>-26$^<em>$ (-26$^</em>$)</td>
<td>.01 (-08)</td>
<td>.08$^<em>$ (09$^</em>$)</td>
<td>.27 / .07$^*$</td>
</tr>
<tr>
<td>Conduct Disorder</td>
<td>.03 (.06)</td>
<td>.15$^*$ (09)</td>
<td>.16$^<em>$ (11$^</em>$)</td>
<td>.18 / .03$^*$</td>
</tr>
<tr>
<td>Oppositional Defiant Disorder</td>
<td>-11$^*$ (-02)</td>
<td>.45$^<em>$ (26$^</em>$)</td>
<td>.48$^<em>$ (33$^</em>$)</td>
<td>.53 / .28$^*$</td>
</tr>
<tr>
<td>Attention Deficit/ Hyperactivity Disorder</td>
<td>-15$^<em>$ (-11$^</em>$)</td>
<td>.09$^<em>$ (-13$^</em>$)</td>
<td>.30$^<em>$ (35$^</em>$)</td>
<td>.33 / .11$^*$</td>
</tr>
</tbody>
</table>

*Note. Combined HBN development and evaluation samples, N = 481. Regressions analyses included all three HBN-Tri scales as predictors of each psychopathology-related variable. HBN = Healthy Brain Network; K-SADS = Kiddy Schedule for Affective Disorders and Schizophrenia.

+$p < .001.$

$^{*}p < .01.$
analyses for the two samples were negligible ($\beta_s = -0.06$ and .05, $t_s = -1.64$ and .73, $p_s = .10$ and .47, respectively).

**KSADS**

Within the combined (Release 1 and 2) HBN sample, the HBN triarchic scales evidenced expected patterns of associations with K-SADS diagnostic composites (Table 3). Specifically, HBN-Boldness correlated to a strong negative degree with internalizing symptomatology ($r = -0.44$, $p < .001$), whereas HBN-Disinhibition showed a contrasting positive association with symptomatology of this type ($r = .10$, $p = .03$). HBN Meanness was unassociated with the KSADS internalizing composite. When the three HBN-Tri scales were included as concurrent predictors in a regression analysis, only HBN Boldness emerged as a significant unique predictor of internalizing symptomatology ($\beta = -0.44$, $t = -10.60$, $p < .001$). Unique predictive relations for HBN Meanness and Disinhibition in this analysis were negligible ($\beta_s = -0.07$ and .07, respectively, $t_s = -1.32$ and 1.33, $p_s = .19$ and .18).

At the bivariate level, the KSADS externalizing composite showed strong positive associations with both HBN Meanness and Disinhibition ($r_s = .46$ and .49, respectively, $p_s < .001$), and a weak negative association with HBN Boldness ($r = -0.09$, $p = .04$). In the regression model incorporating the three HBN-Tri scales as predictors, unique predictive relationships were evident for Meanness and Disinhibition ($\beta_s = .26$ and .34, respectively, $t_s = 5.54$ and 7.15, $p_s < .001$), but not Boldness ($\beta = .00$, $t = -0.11$, $p = .92$).

Lifetime ADHD diagnosis showed a moderate positive correlation with HBN Disinhibition at the zero-order level ($r = .30$, $p < .001$), and weak positive and negative associations, respectively, with HBN Meanness and Boldness ($r_s = .09$ and $-.15$, $p_s = .04$ and .001, respectively). The regression analysis examining associations for the three HBN-Tri scales as concurrent predictors of ADHD diagnosis revealed a positive association for HBN Disinhibition ($\beta = .35$, $t = 6.62$, $p < .001$), and weak negative associations for HBN Boldness and Meanness ($\beta_s = -.11$ and $-.13$, $t_s = -2.55$ and $-2.35$, $p_s = .01$ and .02, respectively).

Additional analyses were conducted to further examine specific associations of the HBN-Tri scales with individual lifetime diagnoses (Table 4). Consistent with associations observed with the broad Internalizing composite, HBN Boldness was negatively related to each Internalizing diagnosis ($r_s$ ranged from $-0.11$ to $-0.35$, $p_s < .05$). These associations for Boldness remained significant in regression analyses incorporating the other triarchic traits ($\beta_s$ ranging from $-0.09$ to $-0.35$, $p_s < .05$), and a small positive association was evident for Disinhibition with Specific Phobia ($\beta = .11$, $p < .05$). At the bivariate level, lifetime conduct disorder and ODD each showed similar-level positive associations with Meanness and Disinhibition (for conduct disorder, $r_s = .15$ and .16, respectively, $p_s < .001$; for ODD, $r_s = .45$ and .48, $p_s < .001$). However, in models employing the traits as concurrent predictors, conduct disorder was predicted by Disinhibition alone ($\beta = .11$, $p = .04$), whereas ODD was predicted by both Meanness and Disinhibition ($\beta_s = .26$ and .33, $p_s < .001$).

**Exploratory tests of interaction effects**

To test for possible interactive effects of pairs of HBN-Tri scales in predicting psychopathology, KSADS- and CBCL-based psychopathology were regressed onto HBN-Tri scores and their product terms (i.e., Boldness x Meanness, Boldness x Disinhibition, Meanness x Disinhibition). The Meanness x
Disinhibition interaction term emerged as significant in predicting CBCL externalizing in the combined HBN and MTurk samples, ($b$ = .16 and .14, $p < .001$, respectively), and in predicting KSADS externalizing in the combined HBN sample ($\beta = .16, p < .001$). Subsequent probing of this interaction effect through simple slopes analyses (see Figures 1a-c) revealed, across samples (HBN and MTurk) and assessment modalities (i.e., CBCL report and KSADS interview), a positive association between Meanness and externalizing symptomatology among individuals with high and moderate levels of Disinhibition (HBN KSADS, $b$ = .368 and .222, $ts = 5.10$ and 3.83, $ps < .001$; HBN CBCL, $b$ = .301 and .178, $ts = 8.90$ and 6.36, $ps < .001$; MTurk CBCL, $b$ = .471 and .260, $ts = 6.11$ and 4.06, $ps < .001$), but not among those low in disinhibition (HBN KSADS, $\beta = .076, t = 1.05, p = .30$; HBN CBCL, $\beta = .055, t = 1.63, p = .10$; MTurk CBCL, $\beta = .049, t = .64, p = .26$).

**Discussion**

Our major study aim was to examine shared and unique associations of the traits of the triarchic model with internalizing and externalizing psychopathology in young children. Results demonstrated that the triarchic model traits can be effectively represented in young children, consistent with the original framing of the triarchic model as a neurobehavioral developmental model with direct links to the broader literature on temperament – which includes reference to dispositional fearlessness, affiliation, and effortful control. Importantly, extending previous work with adults (Patrick & Drislane, 2015) and adolescents (e.g., Kyranides et al., 2017; Sica et al., 2019), the current work documented overlapping and unique associations of parent-rated triarchic traits with criterion measures of psychopathology assessed using a different modality of measurement (i.e., structured clinical interview). The current work provides a foundation for further developmental research directed at clarifying the role that core neurobehavioral dispositions play in mental health problems.

**Development and evaluation of the HBN-Tri scales**

Applying procedures used in previous research with adults (Brislin et al., 2019; Hall et al., 2014), results from our work indicate that the triarchic traits can be successfully operationalized in young children using items from existing multi-trait inventories; the final HBN-Tri scales demonstrated good internal consistencies across participant samples and expected intercorrelations in the two HBN samples. Within the MTurk sample, a higher-than-expected positive correlation was evident between the Meanness and Disinhibition scales, and these scales each showed higher-than-expected negative correlations with Boldness. This contrasts somewhat with findings for self-report based operationalizations in adult samples, where modest positive and near-zero correlations have generally been found for meanness and disinhibition scales, respectively, with boldness. However, observed associations in our study are consistent with findings from other work utilizing data for informant-report based triarchic scales collected via the MTurk platform (e.g., Latzman et al., 2019) – suggesting that this mode of assessment may amplify associations among the three traits as perceived in others. Taken together, the replicability of informant-report operationalizations of the triarchic scales, as well as results consistent with prior work across developmental ages (e.g., adolescents, Brislin et al., 2019; adults, Latzman et al., 2019; Hall et al., 2014; Brislin et al., 2015), is promising and indicates a potentially valuable investigative avenue for advancing the understanding of developmental liability for psychopathology, particularly in young children.

**Associations among triarchic traits and psychopathology**

Across two independent cross-validation samples (i.e., HBN Release 2 and MTurk), the three triarchic scales evidenced significant associations with CBCL Internalizing, Externalizing, and Attention Problems, although the magnitude and direction of these associations varied somewhat. More specifically, and consistent with hypotheses, HBN Boldness emerged as the strongest predictor of the KSADS internalizing composite and CBCL internalizing scores. These findings, which were consistent across assessment modalities and datasets, are generally consistent with prior work (Biederman et al., 2001; Reznick et al., 1988; Schwartz, Snidman, & Kagan, 1999) and suggest that dispositional elements of Boldness, such as fearlessness and immunity to stressors, may be protective against internalizing symptomatology.

The HBN Meanness scale evidenced predictive associations with both internalizing and externalizing symptomatology, as indexed by the CBCL, to a similar degree in both cross-validation samples, but was predictive of externalizing but not internalizing problems as assessed by the KSADS in the Release 2 HBN sample. An extensive literature demonstrates that characteristics of meanness (i.e., low affiliative tendency, callous-unemotionality, antagonism) predict externalizing behaviors (Frick et al., 2014; Frick & White, 2008; Kimonis et al., 2006; McMahon, Witkiewitz, Kotler, 2010; Pardini, Lochman, & Powell, 2007; Shirtcliff et al., 2009; Viding et al., 2005; White & Frick, 2010). However, findings regarding the association of meanness with internalizing problems have been mixed. Although some prior work has found meanness to be associated with internalizing problems in general (e.g., Essau, Sasagawa, & Frick, 2006), other work points to a more specific association with withdrawn behavior (e.g., Ezpeleta et al., 2015; Stadler et al., 2011; Waller et al., 2015), which is an integral component of CBCL internalizing. Consistent with this, post-hoc regression analyses revealed HBN Meanness to be a significant predictor of problematic tendencies indexed by the CBCL Withdrawn-Depressed scale ($\beta = .472, t = 5.46, p < .001$), while being unrelated to the CBCL Anxious-Depressed scale ($\beta = .051, t = 0.59, p > .10$). This association may reflect a lack of interest in social reciprocity and interpersonal bonding on
the part of individuals with high levels of meanness, which may be perceived by parents as withdrawn behavior. Additionally, peer rejection and low self-esteem have been shown to be associated with meanness-related traits (Barry et al., 2008; Fanti, 2013; Fontaine et al., 2011; Piatigorsky & Hinshaw 2004; Waller et al., 2016), which may contribute further to internalizing problems (e.g., Ladd, 2006). HBN Disinhibition strongly predicted CBCL Attention Problems and KSADS lifetime ADHD diagnosis, as well as externalizing symptoms more broadly, across both samples and when accounting for variance shared among the triarchic scales. These results are consistent with a larger literature demonstrating that individuals low in effortful control capacity tend to experience difficulties with attention and behavioral regulation, particularly in conjunction with hostile negative emotionality characteristic of trait disinhibition (Calkins & Fox, 2002; Eisenberg et al., 2005; Muris & Ollendick, 2005). Associations between HBN Disinhibition and the KSADS internalizing composite were weaker than expected based on existing literature (e.g., Calkins & Fox, 2002; Latzman et al., 2019; Venables et al., 2017). This may be due to the relatively low lifetime prevalence of distress-based diagnoses (i.e., MDD and GAD) in the HBN cross-validation sample, resulting in internalizing composite scores that largely reflected fear-based diagnoses (i.e., specific phobia, social phobia, and separation anxiety). Whereas prior work has shown high levels of disinhibition to be more strongly associated with distress-related symptomatology, which is marked by negative affectivity and emotion dysregulation (e.g., Nelson et al., 2016), fear disorders have been shown to relate more strongly to traits reflecting fear/fearlessness (i.e., boldness) but only weakly to disinhibition (Latzman et al., 2020; Venables et al., 2017). Indeed, CBCL-assessed internalizing, which indexes distress and fear symptomatology in continuous-dimensional terms, showed expected strong-positive associations with disinhibition at the bivariate level.

Finally, exploratory analyses were performed to test for possible interactions between triarchic traits in accounting for psychopathology. Across samples, and across criterion-measurement modalities (i.e., parent-reported based CBCL and interview-based KSADS), the association between disinhibition and externalizing psychopathology varied by level of meanness. Of note, the CBCL and KSADS externalizing composites captured oppositional, rule-breaking, and aggressive behaviors specifically, as the CBCL Attention Problems scale and the KSADS ADHD diagnosis were excluded from these composites and analyzed separately. Consequently, our findings suggest the possibility that in young children, high disinhibition may contribute more to oppositional-aggressive externalizing behavior when accompanied by high meanness than in isolation. It may be that heightened meanness provides the antagonistic element that is salient in antisocial-aggressive expressions of externalizing proneness (Waller et al., 2017).

Limitations and future directions

Along with significant strengths of the current study, certain limitations also warrant discussion. First, all measures employed in this work relied on mono-informant (i.e., parental) report, apart from the K-SADS measures available for HBN study participants, which were based on diagnostic consensus of child, as well as parent, responses to interview questions. It will be valuable in future studies to collect data from multiple informants (e.g., child, mother, and father) in order to more effectively evaluate the role of informant bias and method variance in observed validity coefficients.

Another limitation pertains to the use of categorical lifetime diagnoses from the K-SADS in this particularly young sample. Low base rates of particular disorders influenced the psychopathology composite scores and their associations with the triarchic trait scales. As noted earlier, given the very young age of HBN study participants, rates of distress disorders (MDD, GAD) in this sample were very low, resulting in an internalizing composite predominated by fear-based pathology. Additionally, some disorders had to be excluded entirely from analysis due to exceedingly low base rates (i.e., PTSD, panic, agoraphobia, substance use). Rather, the use of symptom-level diagnostic data would allow for more fine-grained conceptualization and assessment of symptom profiles and developmental factors. Notably, however, the results for dimensional CBCL summary scores, and the consistency of associations observed across measurement modalities and samples, bolster the findings for triarchic traits in predicting clinical diagnoses.

Final limitations pertain to the nature of the samples. Some concerns have been raised about the quality of data obtained via MTurk (for a review, see Hauser et al., 2018; Kennedy et al., 2018). With these concerns in mind, we took specific steps to optimize data integrity. These included limiting respondents to US-geographical regions, quality-checking free response questions to detect language comprehension issues, and excluding participants for whom Human Intelligence Tasks (HIT) ratios fell below 95% or who exhibited clearly biased response patterns (i.e., 90% of items answered using the same response option).

Lastly, the current analyses were exclusively cross-sectional in nature. To establish trait measures as risk factors for psychopathology as opposed to correlates, follow-up assessments of psychopathology at later points in time will be needed. Fortunately, the HBN study was designed as a prospective-longitudinal study, and therefore additional assessments of participants will be conducted at future time points for use in follow-up analyses. Indeed, this element of the HBN study was an important impetus for us to develop triarchic scale measures for use with this dataset.

Conclusion

Limitations notwithstanding, the current study provides notable insights into associations between triarchic neurobehavioral trait dimensions and psychopathology in young children. Although initially developed to characterize psychopathy in neurobehavioral terms (Patrick et al., 2009), the current study findings support the utility of the triarchic model for research on dispositional risk for common mental disorders of various types. In this regard, findings
demonstrate the ability to downwardly extend the operation-
ization of triarchic trait dimensions to young children using scale-construction procedures that have proven effective with adults (e.g., Brislin et al., 2015; Drislane et al., 2018; Hall et al., 2014) and adolescents (Brislin et al., 2019). In addition to being effective, the strategy of developing triarchic scales from items included in existing datasets is clearly efficient, in that it allows for testing of novel hypotheses using specialized samples and distinctive measures available in particular study protocols.

A feature of the triarchic model of great value to the study of developmental psychopathology is its focus on traits with referents in neurobiology and behavioral performance as well as reported psychological experience. As such, the triarchic model traits can be helpful for linking psychopathology phenotypes (e.g., clinical diagnoses or symptom counts) to core neurobehavioral constructs relevant to emotion, cognition, motivation, and social behavior. More specifically, the constructs of the triarchic model—which represent trait counterparts to biobehavioral processes of threat reactivity, affiliative capacity, and inhibitory control—provide a concrete means for advancing understanding of psychopathology in terms of transdiagnostic processes operationalized through different modalities (“units”) of measurement (Insel & Cuthbert, 2009; Kozak & Cuthbert, 2016). Projects like the HBN study that include neurophysiological and task-performance measures along with report-based data can be uniquely valuable in this regard. As a final point, results of the current study, in conjunction with the large and growing literature on the triarchic model, underscore the importance of considering neurobehavioral trait dimensions in explicating pathways to psychopathological outcomes in children.

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**Data Availability Statement**

This manuscript was prepared using a limited access dataset obtained from the Child Mind Institute Biobank, Healthy Brain Network. This manuscript reflects the views of the authors and does not necessarily reflect the opinions or views of the Child Mind Institute. Data collected via Child Mind Institute Healthy Brain Network is available via [http://fcon_1000.projects.nitrc.org/indi/cmi_healthy_brain_network/index.html](http://fcon_1000.projects.nitrc.org/indi/cmi_healthy_brain_network/index.html); data usage agreement is required.

**References**


