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Temperament factors and dimensional, latent bifactor models of child psychopathology: Transdiagnostic and specific associations in two youth samples

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Abstract

Common emotional and behavioral symptoms co-occur and are associated with core temperament factors. This study investigated links between temperament and dimensional, latent psychopathology factors, including a general common psychopathology factor (p factor) and specific latent internalizing and externalizing liabilities, as captured by a bifactor model, in two independent samples of youth. Specifically, we tested the hypothesis that temperament factors of negative affectivity (NA), positive affectivity (PA), and effortful control (EC) could serve as both transdiagnostic and specific risks in relation to recent bifactor models of child psychopathology. Sample 1 included 571 youth (average age 13.6, SD = 2.37, range 9.3–17.5) with both youth and parent report. Sample 2 included 554 preadolescent children (average age 7.7, SD = 1.35, range = 5–11 years) with parent report. Structural equation modeling showed that the latent bifactor models fit in both samples. Replicated in both samples, the p factor was associated with lower EC and higher NA (transdiagnostic risks). Several specific risks replicated in both samples after controlling for co-occurring symptoms via the p factor: internalizing was associated with higher NA and lower PA, lower EC related to externalizing problems.

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Disclosure of interest

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Keywords

p factor; bifactor latent models; child psychopathology; risk

1. Introduction

Decades of research examining child psychopathology have produced two clear facts. First, common psychiatric syndromes, including internalizing problems of anxiety and depression, as well as externalizing problems of hyperactivity and conduct problems, significantly co-occur (Angold et al., 1999). Second, individual differences in temperament traits, especially negative affectivity, positive affectivity, and effortful control, are associated with child psychopathology (DePauw and Mervielde, 2010). However, little research has systematically and rigorously integrated these two core findings to understand whether all three main temperament factors operate as transdiagnostic risks, that broadly relate to psychopathology, and particular risks to specific syndromes, especially when considered in light of recent latent dimensional, structural models of psychopathology (e.g., p factor, Caspi et al., 2014). Specifically, which temperament factors relate broadly to the p factor, that represents a common latent liability to general psychopathology, and which temperament dimensions are linked more specifically to particular aspects of child psychopathology (internalizing or externalizing problems)? To address these questions, this study examined data from two independent samples of differently aged youth.

1.1 Latent dimensional structural models of psychopathology and symptom co-occurrence

Multiple studies provided evidence for latent dimensional structural models to organize psychopathology across different levels (for review, Hankin et al., 2016). Investigators have applied bifactor modeling and demonstrated that common psychopathology (e.g., mood, anxiety, conduct and aggression) could be best structured by a general psychopathology latent factor (the p factor) as well as unique internalizing and externalizing latent factors (Caspi et al., 2014; Laceulle et al. 2015; Lahey et al., 2012; Lahey et al., 2014; Murray et al., 2016; Olino et al., 2014; Patalay et al., 2015; Snyder et al., 2016). The p factor captures, in a single latent variable, the co-occurrence that is common across all measured psychopathology symptoms. After statistically accounting for shared variance common across all psychopathology symptoms via the p factor, unique covariance that remains among these psychopathology symptoms is independently captured and organized by additional unique factors, specifically, latent internalizing and externalizing liability dimensions.

1.2 Temperament factors and child psychopathology

1.2.1 Effortful control—Effortful control (EC) involves the recruitment of attentional and behavioral processes to self-regulate and guide behavior toward a goal (Rothbart, 2007). Historically, poor EC has been examined more extensively as risk to externalizing problems, such as conduct problems, aggression, and hyperactivity. More recently, poor EC has been shown to associate more broadly beyond externalizing to most forms of psychopathology (Beauchaine and Thayer, 2015; Snyder et al., 2015), including depression, anxiety, bipolar

disorder, schizophrenia, conduct, and ADHD. Such data are consistent with EC conferring a broad-based, transdiagnostic risk to child psychopathology, so we hypothesize that poor EC is associated with the p factor. At the same time, past work shows individual links between poor EC and specific internalizing (Vasey et al., 2013) and externalizing problems (Beauchaine and McNulty, 2013), so there may also be unique associations between low EC and the specific internalizing and externalizing latent dimensions after controlling for the p factor of general psychopathology.

1.2.2 Negative and positive affectivity—Negative affectivity (NA) refers to individual differences in the tendency to experience negative moods, including sadness, worry, and anger and characterizes how easily these are aroused (Rothbart, 2007). NA is linked to internalizing and externalizing symptoms (Kotov et al., 2010; Lahey, 2009; Nigg, 2006; Ormel et al., 2013). These findings suggest that NA may serve as a broad-based, transdiagnostic risk to child psychopathology, so we hypothesize that high NA is linked with the p factor. Still, given associations between NA and individual disorders characterized by internalizing and externalizing facets, there may be specific links between high NA and the particular internalizing and externalizing dimensions after controlling for the p factor.

The temperament dimension of positive affectivity (trait PA) can be defined as individual differences in the propensity to experience positive emotions. Low PA correlates with depression, social anxiety and some other anxiety disorders (Clark et al., 1994; Davis and Suveg, 2013; Kotov et al., 2010). Taken together, these findings suggest that low PA may relate to the p factor and especially correlate with the latent internalizing liability, whereas links with the externalizing liability dimension may be much weaker.

1.2.3 Temperament and comorbid child psychopathology—Extensive literature has examined EC, NA and PA, and associations with child psychopathology (Clark, 2005; De Pauw and Mervielde, 2010; Hankin et al., 2016; Muris and Ollendick, 2005; Nigg, 2006; Tackett, 2006). These reviews conclude that each temperament dimension by itself, as a main effect, is associated with various forms of child psychopathology. Moreover, each review calls for additional research to examine all three temperament dimensions together as they relate to, and seek to explain, the general co-occurrence of child psychopathology and unique symptom syndrome expressions. Considerably less research has investigated this issue of how all three temperament dimensions are associated with specificity and overlap in child psychopathology. All three dimensions are needed as indicators of individual differences in temperament traits to more fully characterize risk to child psychopathology, as past work shows that different psychopathologies can best be understood via a multivariate individual difference trait perspective (Clark, 2005; Trull and Sher, 1994). Specifically, the three temperament dimensions are intercorrelated, so examining one temperament dimension without the others could be misleading, as effects could be spurious due to intercorrelations among temperament traits.

Less is known about how all three temperament factors relate to a general dimension of psychopathology as well as specific aspects of psychopathology when child psychopathology is conceptualized as, and analyzed via, a bifactor model of psychopathology. Among adults, the p factor was associated with poor EC and trait NA

(Caspi et al., 2014); PA was not investigated. After taking into account the p factor, trait NA's association with externalizing problems became non-significant, whereas the association between NA and internalizing problems remained significant. In children and adolescents (ages 9–17), NE was associated with the general psychopathology dimension (Tackett et al., 2013), although PA and EC were not examined. Last, in a community sample of preschoolers, Olino and colleagues (2014) found that parent reports of child temperament related to latent psychopathology dimensions. The general psychopathology factor was associated with EC negatively, and positively with surgency (a specific aspect of PA) and NA; internalizing specific factor was associated with lower surgency; and externalizing specific dimension was correlated with lower EC and higher surgency. Thus, in addition to serving as a broad transdiagnostic risk factor (i.e., predicting the p factor), temperament traits may also serve as risk for specific psychopathology dimensions.

1.3 The current study

We sought to advance knowledge on the links between temperament and child psychopathology, especially when modeled via a latent dimensional, bifactor structural organization of psychopathology. Past work has tended to study temperament-psychopathology relations without including all three temperament dimensions simultaneously and without explicit consideration of psychopathology co-occurrence. Relatively little past work has examined all three temperament dimensions in relation to multiple forms of psychopathology when structured via recent bifactor latent psychopathology models (cf., Olino et al., 2014). Further, no prior study has evaluated developmental differences in the magnitude and pattern of associations between temperament factors and the latent dimensions of psychopathology between preadolescent children and adolescents. We examined relationships between temperament factors and latent dimensional factors of psychopathology, based on the bifactor p factor model, in two independent samples of children and adolescents.

2. Study 1

2.1. Method

2.1.1. Participants—We used data from 571 youth-parent pairs. On average, child participants were 13.58 years old (SD = 2.37, range = 9.3–17.5). Youth and a parent from the general community were recruited at two sites, University of Denver (DU) and Rutgers University (RU), for the Gene, Environment, Mood (GEM) Study (see Hankin et al., 2015, for study and sample details). Youth were 55.5% female, and identified their ethnicity as 12% Latino and race as 70% Caucasian, 12% African American, 9% Asian/Pacific Islander, and 9% or other/multiracial. Median annual family income was $86,500; SES, determined via parents' education and specific occupations (Adams and Weakliem, 2011), was 48.86 (SD = 11.35) and 18.3% of youth received free/reduced lunch. Caretakers who provided parent report were 85% mothers. In general, psychopathology levels for the sample closely matched those of population epidemiological studies (Costello et al. 2016): in total, 24% of youth in the sample had a history of major depressive disorder before or during the study period, 16.3% of youth in the sample had a history of an anxiety disorder, 5.2% had ADHD

symptoms in the clinical range, and 5.6% had conduct problems in the clinical range (Arnett et al., 2015; Hankin et al., 2015).

2.1.2. Procedure—Both youth and parent reports about youth psychopathology were collected for all questionnaires, except the Swanson, Nolan, and Pelham scale (*SNAP-IV*), which was completed by parents only. All procedures were approved by the University of Denver and Rutgers University Institutional Review Boards. Parents provided informed consent and youth provided informed assent.

2.1.3. Psychopathology measures

2.1.3a Children's Depression Inventory (CDI; Kovacs, 1985): The CDI assesses depressive symptoms in children and adolescents. The CDI has good reliability and validity (Klein et al., 2005). Internal consistency for child report was 0.88 and 0.83 for parent report.

2.1.3b Manifest Anxiety Scale for Children (MASC; March et al., 1997): The MASC assesses anxious symptoms in children and adolescents via subscales (1) physical symptoms of anxiety, (2) harm avoidance, (3) social anxiety, and (4) separation anxiety/panic. Harm avoidance was not used because it does not assess anxiety but rather risk-aversion (Snyder et al., 2015). The MASC has good reliability and validity (March et al., 1997). Internal consistencies for child report were all above 0.81 and 0.80 for parent report.

2.1.3c Child Behavior Checklist (CBCL/YSR): The Child Behavior Checklist (CBCL) and Youth Self Report (YSR) are widely used and validated measures of youth mental health and behavioral problems. The Oppositional Defiant (ODD) and Conduct (CD) DSM-oriented scales of the CBCL and YSR were used. They have good reliability and validity (Achenbach and Rescorla, 2001). Internal consistency for child report was 0.82 and 0.91 for parent report.

2.1.3d Aggression scale of the Early Adolescent Temperament Questionnaire Revised (EATQ-R, Ellis and Rothbart, 2001): This scale assesses hostile reactivity and aggressive physical and verbal actions in children and adolescents. The aggression scale has good reliability and validity (Snyder et al., 2015). Internal consistency for child report was 0.81 and 0.82 for parent report.

2.1.3e MTA Swanson, Nolan, and Pelham scale (MTA SNAP-IV): Parents completed the NIMH Collaborative Multisite Multimodal Treatment Study of Children with Attention-Deficit/Hyperactivity Disorder version of the SNAP-IV (Swanson et al., 2001). It includes the 18 DSM-IV criteria for ADHD. It has good reliability and validity (Swanson et al., 2001). Internal consistency was 0.94 for inattention and 0.90 for hyperactivity.

2.1.4. Temperament measures

2.1.4a Effortful control: EC was assessed via the Early Adolescent Temperament Questionnaire Revised (EATQ-R, Ellis and Rothbart, 2001). The EC scale includes attentional, inhibitory and activation control. Higher scores indicate better cognitive control.

The EC scale has good reliability and validity (Snyder et al., 2015). Internal consistency was 0.87.

2.1.4b Negative and positive affectivity: NA and PA were assessed with the Positive and Negative Affect Scale for Children (PANAS-C; Laurent et al., 1999). The PA and NA subscales have good reliability and validity (Laurent et al., 1999). Many past studies have used the PANAS-C to assess trait individual differences in PA and NA in youth (e.g., Phillips et al. 2002; see review by Muris and Ollendick, 2005). In particular, the PANAS-C is optimal for assessing individual differences in valence of temperament emotionality (Zeman et al., 2007), as the valence aspect of PA and NA is deemed as fundamental to assessing temperament traits of PA and NA (Watson, 2000). Internal consistency was 0.89 for NA and 0.83 for PA.

2.1.5. Statistical analysis—Structural equation modeling was conducted in Mplus (Muthén and Muthén, 2012) using full information maximum likelihood (FIML) estimation to handle missing data. Missing data rates for all measures administered were low (≤ 4%). For all models, we considered various factors to evaluate best fitting models, including parsimony and conceptual consistency, but also conservative “rules of thumb” in which good fit was defined as root mean square error of approximation < 0.06, comparative fit index > 0.95, Tucker–Lewis index > 0.95, and standardized root mean square residual < 0.08 (Hu and Bentler, 1999). Each individual fit index has strengths and limitations; no consensus has been reached on a single fit index to evaluate model fit (Loehlin, 2004).

2.1.5a P factor measurement model: The p factor model was identical to that in Snyder, Young & Hankin (in press), which reports the full model development description and results in this data set (T1 model). Briefly, all measures (measure factors when two reporters, manifest measures when one reporter) were loaded onto a common factor (p factor), as well as their specific factor that represent the unique variance associated with internalizing and externalizing psychopathology not accounted for by the p factor. In addition, reporter factors and random intercepts were included to account for variance related to reporter characteristics (e.g., social desirability or negativity bias effects; e.g., Pettersson and Turkheimer, 2010) and idiosyncratic response patterns (Maydieu-Olivares and Coffman, 2006). It is well established that parent and youth reports of child psychopathology are only mildly to moderately correlated (Achenbach et al., 1987). To address these informant effects and take full advantage of having multiple reporters of child psychopathological symptoms, we explicitly included latent reporter factors (parent and child reports from symptom measures loading onto these reporter factors) to account for and remove variance specific to informant characteristics so that the latent psychopathology factors (p factor, internalizing and externalizing dimensions) are free of error, informant bias, and problematic response patterns. Residual correlations were included as suggested by modification indices. This model achieved good fit (CFI = 0.97, TLI = 0.95, RMSEA = 0.054, SRMR = 0.044).

2.1.5b Temperament measurement models: NA, PA, and EC were modeled respectively with single latent factors in which items from the NA subscale, the PA subscale, and the EC

subscale loaded onto their respective temperament factors. Each temperament factor was first checked and modified as necessary to achieve acceptable fit. First, each model was checked for adequate item loadings; 0.30 was chosen as a cut-off for acceptability (Kline, 2016), below which items were removed. This resulted in removal of three EC items (15 total items included) and one PA item (12 items); no NA items were excluded (15 items). The EC (CFI = 0.94, TLI =0.92, RMSEA = 0.054, SRMR = 0.042), NA (CFI = 0.94, TLI = 0.93, RMSEA = 0.065, SRMR = 0.046) and PA (CFI = 0.94, TLI = 0.92, RMSEA = 0.085, SRMR = 0.042) have acceptable fit.

2.1.5c Structural models: Associations between the temperament factors and p factor latent dimensions were assessed in two ways. First, models were conducted in which p, internalizing-specific and externalizing-specific factors were correlated with the EC, NA and PA factors in separate analyses. Second, given that the temperament factors are themselves correlated (see results), multiple regression analyses were performed predicting each of the p, internalizing-specific and externalizing-specific factors with the EC, NA and PA factors to determine the unique relationship of each temperament dimensions with latent dimensions of psychopathology, controlling for the other temperament factors.

2.2. Results

2.2.1 Correlation analyses—Results are in Table 1. Full model tables with factor loadings are available in Supplementary Materials (Tables S1–S3). The p factor was strongly negatively correlated with EC; lower EC predicted higher common psychopathology. The p factor was positively correlated with NA and negatively with PA; higher NA and lower PA predicted higher common psychopathology. The internalizing-specific factor was positively correlated with NA, weakly positively correlated with PA, but not correlated with EC. The externalizing-specific factor was negatively correlated with EC, positively with NA, and had no correlation with PA.

Temperament factors were correlated: EC was negatively correlated with NA ($r = -0.419$, $p < 0.05$), and positively correlated with PA ($r = 0.356$, $p < 0.05$), while NA and PA were negatively correlated ($r = -0.260$, $p < 0.05$). Thus, multiple regression analyses were next conducted to determine the incremental association of each temperament factor relating to latent psychopathology dimensions.

2.2.2. Regression analyses—Results are reported in the bottom half of Table 1 and depicted in Figure 1 (top). All effects control for the other two temperament factors (e.g., EC controlling for NA and PA, etc.). The p factor was associated negatively with EC, positively with NA, and weakly negatively with PA. The internalizing-specific factor was positively associated with NA, and weakly negatively with EC and PA. The externalizing-specific factor was associated with EC, with no effect of NA or PA.

3. Study 2

3.1. Method

3.1.1. Participants—We used data from 554 child-mother pairs. On average, children were 7.7 years old (SD = 1.35, range = 5–11 years). Participants were recruited through hospitals in the greater Los Angeles Area. Youth were 49.8% female, and identified their ethnicity as 46% Hispanic and race as 67% White, 6% African American, 5% Asian/Pacific Islander, and 21% multiracial. Median annual family income was $75,000. Rates of clinically elevated symptoms on the Child Behavior Checklist (CBCL) DSM-oriented scales ranged from 4% for affective problems and ADHD to 9% for anxiety, consistent with epidemiological studies (Costello et al., 2016).

3.1.2. Procedure—Mothers reported on their child's temperament and psychopathology. All procedures were approved by the University of California, Irvine and the Long Beach Memorial Medical Center Institutional Review Boards. Parents provided informed consent and youth provided informed assent.

3.1.3. Measures

3.1.3a Child psychopathology: The CBCL was used to assess children's psychopathology via raw scores on the empirically-based subscales: Aggressive Behavior (α = 0.88), Anxious/Depressed (α = 0.73), Attention Problems (α = 0.80), Rule-Breaking Behavior (α = 0.63), Thought Problems (α = 0.64), Somatic Complaints (α = 0.66), Social Problems (α = 0.69), and Withdrawn/Depressed (α = 0.69).

3.1.3b Child temperament: The Children's Behavior Questionnaire (CBQ; Rothbart et al., 2001*)* is a maternal report of child temperament that assesses various subscales combined to tap EC, NA and PA. The following subscales were used: attention focusing (α = 0.65), attention shifting (α = 0.64), inhibition(α = 0.78), impulsivity (α = 0.71), anger/frustration (α = 0.82), fear (α = 0.75), distress (α = 0.60), sadness (α = 0.68), and smiling/laughing (α = 0.80).

3.1.4. Statistical Analysis—The same approach was used for Study 2 as Study 1 using Mplus. Missing data rates for all measures administered were low (≤ 6%); FIML addressed missing data.

3.1.4a P factor measurement model: All measures from the CBCL were loaded onto a common factor (p factor), as well as their specific factors that represent the unique variance associated with internalizing and externalizing psychopathology liabilities not accounted for by the p factor. Specifically, the Anxious/Depressed, Withdrawn/Depressed, and Somatic complaints subscales were loaded onto the Internalizing-specific factor; the Rule-Breaking Behavior, Aggressive Behavior and Attention Problems subscales were loaded onto the Externalizing-specific factor; and all of these subscales plus the CBCL Social Problems and Thought Problems subscales were loaded onto the p factor. This model achieved excellent model fit (CFI = 0.99, TLI = 0.99, RMSEA = 0.015, SRMR = 0.011).

3.1.4b Temperament measurement models: NA, PA, and EC were modeled respectively to comprise single latent factors with appropriate items from the CBQ loading onto respective temperament factors. Specifically, EC was modeled with items from the attention focusing, attention shifting, inhibition, and impulsivity (reversed) subscales; NA was modeled with items from the anger/frustration, fear, distress and sadness subscales; and PA was modeled with items from the smiling/laughing subscale. Each temperament factor was first checked and modified as necessary to achieve acceptable fit. This resulted in inclusion of 26 EC items, 28 NA items, and 13 PA items. EC (CFI = 0.85, TLI = 0.84, RMSEA = 0.059, SRMR = 0.054), NA (CFI = 0.89, TLI = 0.88, RMSEA = 0.046, SRMR = 0.049) and PA (CFI = 0.92, TLI = 0.89, RMSEA = 0.060, SRMR = 0.050) have acceptable fit by some, but not all, indices. When particular scales have lower reliability and poor psychometric qualities, as some have shown with the CBQ (cf., Kotelnikova et al., 2015) and was also true in the current data, CFI and TFI values are reduced and may not be considered as meaningful indices (Kenny, 2012). As other indices had acceptable fit, analyses proceeded with these latent temperament factors.

3.2 Results

3.2.1 Correlation analyses—Results are reported in Table 2. Full model tables with factor loadings are available in Supplementary Materials (Tables S3–S6). The p factor was correlated negatively with EC and positively with NA. There was no correlation with PA. The internalizing-specific factor was negatively correlated with PA and weakly positively with NA and EC. The externalizing-specific factor was negatively correlated with EC, and positively correlated with NA, with no correlation with PA.

3.2.2 Regression analyses—EC was negatively correlated with NA ($r = -0.653$, $p < 0.05$), and weakly positively correlated with PA ($r = 0.130$, $p < 0.05$). NA and PA were not correlated ($r = -.033$, *ns*). Given correlations between the EC and NA factors, these regression models should be interpreted with some caution due to this potential collinearity. All effects control for other temperament factors. Regression analyses are reported in the bottom portion of Table 2 and depicted in Figure 1 (bottom).

The p factor was negatively associated with EC, weakly positively with NA, with no association with PA. The internalizing-specific factor was positively associated with NA, and negatively with PA. Unexpectedly, when controlling for NA and PA there was a positive association between EC and the internalizing specific factor. After controlling for EC, the externalizing-specific factor was negatively associated with EC and NA, and weakly positively associated with PA.

4. Discussion

This study examined the structure of latent dimensions of child psychopathology liabilities in two independent samples from the perspective of new, bifactor models of psychopathology and links between temperament risks with these dimensional liabilities to child psychopathology. Three main sets of findings emerged. First, the p factor, which characterizes a general latent liability to broad co-occurring psychopathology, was obtained in both samples across a wide age range, including pre-adolescent childhood (Sample 2) and

childhood through adolescence (Sample 1). Second, the p factor was associated with low EC and high NA, suggesting that these temperament factors provide broad-based, transdiagnostic risk to general psychopathology. Finally, unique variances in both latent internalizing and externalizing dimensions, independent of the p factor, were associated with temperament factors in meaningful ways that suggest specific associations between temperament and specific psychopathology syndromes.

First, a latent bifactor model that organizes the structure of commonly occurring emotional and behavioral problems and symptoms was obtained in both youth samples. These data importantly replicate and extend the results across different ages ranging from preadolescence (ages 5–11 in Study 2) to late adolescence (ages 9–17 in Study), across different informants (both parent and youth in Study 1; parent only in Study), and across different psychopathology measures. Both studies add to the growing corpus of research that has obtained this bifactor model. These findings, taken together with prior research conducted with adults (Caspi et al., 2014; Greene & Eaton, 2017) and youth (Laceulle et al., 2015; Lahey et al., 2014; Murray et al. 2016; Olino et al., 2014; Patalay et al., 2015; Snyder et al., in press; Tackett et al., 2013), provide strong support for a latent dimensional bifactor model that organizes common manifestations of psychopathology. Overall, the bifactor model, including p factor and unique internalizing and externalizing latent symptom dimensions, ranges across age as an optimal, efficient means of organizing psychopathology structure.

Second, we addressed how latent temperament factors relate to and explain variance in these latent psychopathology dimensions. Temperament traits served as both transdiagnostic and specific risks. Providing broad-transdiagnostic risk to overlapping psychopathology, low EC and higher NA related to the p factor in both samples. These findings replicate and extend other studies examining temperament dimensions with latent bifactor models of psychopathology. In adults NA and EC related to the p factor (Caspi et al., 2014). NE was associated with a general psychopathology factor in 9–17 year olds (Tackett et al., 2013). EC, surgency, and NA related to general psychopathology in preschoolers (Olino et al., 2014). Thus, low EC and high NA confer transdiagnostic risk to general psychopathology as instantiated via the latent p factor.

Additionally, a replicable set of findings was obtained across both studies relating particular temperament dimensions to specific latent psychopathology dimensions after controlling for common general psychopathology via the p factor. Specifically, internalizing symptoms were associated with higher NA and lower PA; low EC related with the externalizing dimension. PA was not associated with externalizing problems in correlational analyses in either sample, which further provides evidence of discriminant validity. Decades of research examined associations between temperament factors and different forms of child psychopathology, but this past corpus of research has been hampered by the co-occurrence among emotional and behavioral problems among youth and relatively few studies simultaneously examining all three major temperament dimensions in concert with multiple forms of psychopathology. The present results are important because they clarify what the unique links are between particular temperament traits and specific dimensions of

psychopathology, when using bifactor models to accurately characterize the structure of child psychopathology.

At the same time, some findings relating temperament factors to latent psychopathology dimensions were specific to the particular samples. First, low PA was associated with the p factor in Sample 1 (ages 9–17), but not Sample 2 (ages 5–11). PA is a multifaceted temperament construct that includes many dimensions, including valence, sociability, reward, and function (Olino, 2016; Zeman et al., 2007). It may be that the association between PA and the p factor depends on the precise nature of temperament PA that is measured in a particular study. For example, Olino and colleagues (2014) in a sample of preschoolers found small associations between general psychopathology and parent reported surgency, one specific aspect of PA that is mostly closely aligned conceptually with the PA valence dimension assessed via the PANAS-C in Sample 1, whereas no association was found when PA was assessed in the same sample via laboratory-based measures of observed PA. Second, the direction of association between EC and the internalizing dimension varied between studies. In Sample 2 (ages 5–11) this association was positive, whereas for Sample 1 (ages 9–17), this association was negative, albeit small in the regressions. Specific internalizing problems may correlate with EC in younger children who may cope through greater behavioral control, at least as reported by mothers (Eisenberg et al., 2001). As youth mature into adolescence, such in Sample 1 (ages 9–17), the literature shows smaller, often negative associations between EC and internalizing problems (Vasey et al., 2013). Last, methodological differences between the two samples may also explain discrepancies. Different informants (combination of parent and child report in Study 1; parent only report in Study 2) and different temperament and psychopathology manifest measures were used. Varying symptom items on different measures can contribute to subtle differences in the composition and nature of the latent factors created, even when the overall p factor structural model was obtained across both studies.

Results have implications for advancing knowledge on temperament and child psychopathology. First, findings help to illuminate the nature and meaning of these latent psychopathology dimensions. There is considerable debate regarding optimal structure and classification of psychopathology (e.g., categorical versus dimensional; Hyman, 2012) with relevance for DSM. More research is being conducted using these latent dimensional models of psychopathology, including bifactor models. For example, NIMH's RDoC initiative emphasizes investigation of psychopathology dimensionally and explaining symptom dimensions via multiple etiological constructs, including negative valence systems (e.g., NA), positive valence (e.g. PA) systems, and cognitive control (e.g., EC). Research on dimensional models of psychopathology will undoubtedly continue and quicken in pace and volume. Research on individual differences in temperament traits provides a promising road map that can connect and explain variance in psychopathology across multiple units of analysis within these NA, PA and EC systems. Moreover, research shows that the p factor, as well as specific internalizing and externalizing latent psychopathology factors, show strong homotypic stability over time in youth (Snyder et al., 2016; Murray et al., 2016) and adults (Greene & Eaton, 2017). Given strong stability of latent psychopathology liabilities, it is important to understand developmental origins and early predictors of these factors. Individual differences in temperament traits represent a prime line of inquiry for seeking to

understand processes that can contribute to the development and maintenance of consistency in psychopathology factors over time.

Findings need to be interpreted in light of strengths and limitations. We used reliable and valid measures that are developmentally appropriate to the age group in each sample to assess conceptually similar temperament traits and child psychopathology symptoms; this means that replication of main findings is robust across methods and samples. Limitations include cross-sectional data. Establishing basic associations, including the direction and magnitude of effects, is a fundamental first step before engaging in future longitudinal prediction in these latent psychopathology dimensions. Second, potential mechanisms that may underlie associations between temperament and latent psychopathology dimensions were not examined. Future research can investigate processes, including learning processes (punishment for NA), reward learning and sensitivity for PA (Olino, 2016), executive functioning process for EC (Snyder et al., 2015), and common genetic influences (Tackett, et al., 2013). Third, only main effect associations were investigated. Future research can examine higher order interactions among temperament dimensions (Vasey et al., 2013) and stressful life events (Gulley et al., 2016). Finally, both samples were recruited from the general community and exhibited relatively high SES. These are not clinical psychiatric samples, and rates of psychopathology and symptom levels are consistent with those observed from past studies of latent bifactor models of psychopathology using general community samples (e.g., Laceulle et al., 2015; Olino et al., 2014; Tackett et al., 2013).

In summary, data from these two independent samples of youth showed that a latent, dimensional structure organizes commonly occurring behavioral and emotional child psychopathology symptoms optimally via a bifactor model consisting of a common, general psychopathology factor (p factor) alongside independent internalizing and externalizing latent liability dimensions. Further, temperament factors were associated with these different psychopathology factors in meaningful ways in children and adolescents. Temperament factors, especially EC and NA, operate as transdiagnostic risks that may confer vulnerability to general psychopathology broadly. All three temperament dimensions showed specific associations to unique internalizing and externalizing symptoms. Taken together, both the co-occurring and unique forms of common emotional and behavioral problems in youth can be understood and characterized succinctly in a multivariate manner via individual differences in temperament factors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

1. Examines bifactor structure of psychopathology in two independent samples of youth
2. Investigates associations between temperament factors and the latent p factor as well as specific internalizing and externalizing latent dimensions.
3. Results show that temperament factors serve as transdiagnostic factors as they are associated with the p factor in both samples.
4. Findings showed that temperament factors operate also as unique risks to specific forms of psychopathology in terms of specific internalizing and externalizing dimensions.

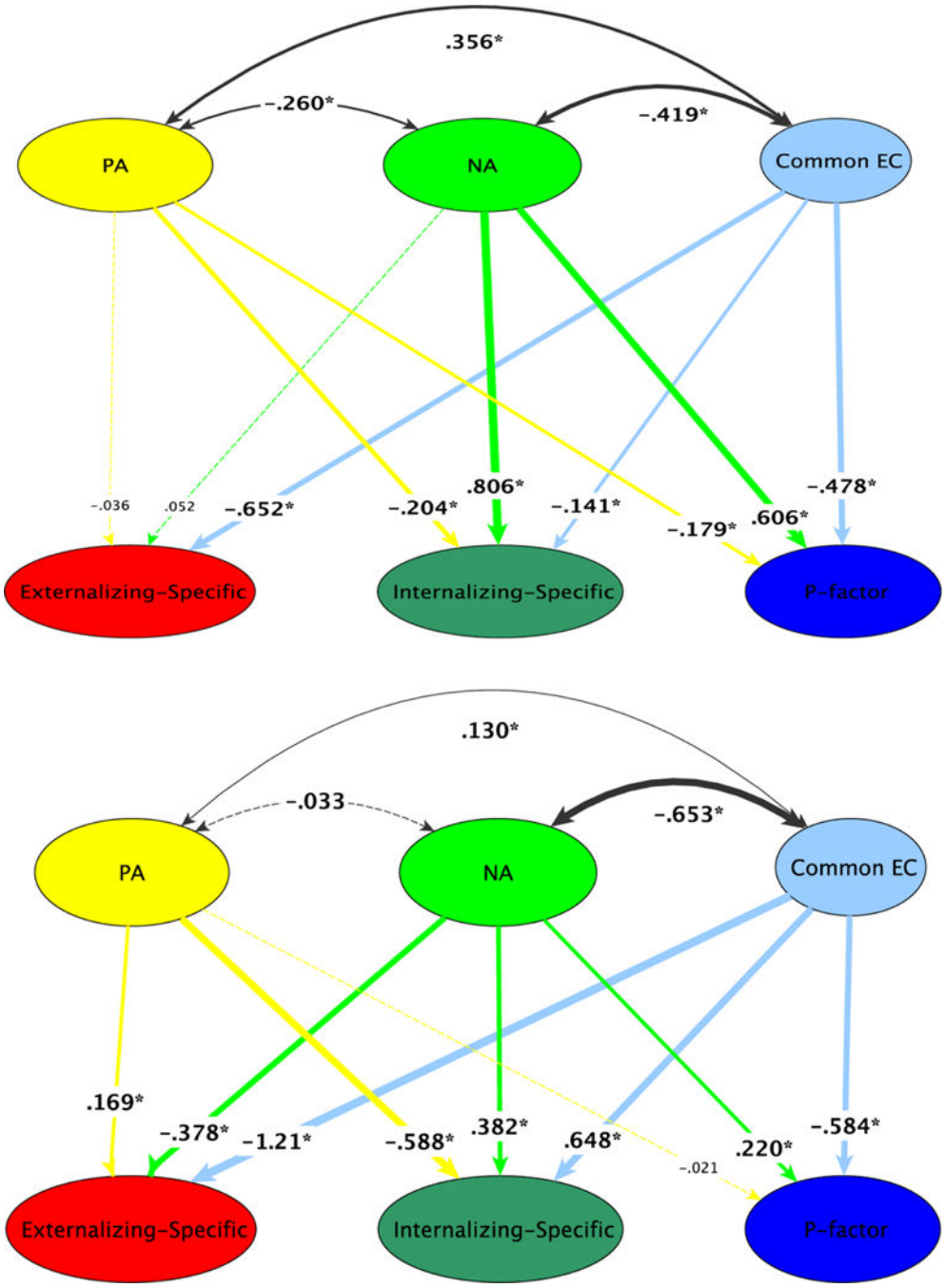

Figure 1.

Associations among latent temperament factors and bifactor model dimensions of child psychopathology based on regression analyses from Sample 1 (top) and Sample 2 (bottom) controlling for overlap among temperament factors.

Table 1

Sample 1 Factor Correlations and Regressions Relating Associations between Latent Temperament Factors and Latent Dimensions of Child Psychopathology from Bifactor Modeling

Model	Psychopathology factor	Temperament factor	Beta (SE)	*p*
Individual correlation models	p factor	EC	**−0.888 (0.057)**	**< 0.001**
		NA	**0.503 (0.068)**	**< 0.001**
		PA	**−0.613 (0.065)**	**< 0.001**
	Internalizing-specific	EC	0.015 (0.071)	0.831
		NA	**0.863 (0.066)**	**< 0.001**
		PA	**0.149 (0.066)**	**0.024**
	Externalizing-specific	EC	**−0.351 (0.084)**	**< 0.001**
		NA	**0.345 (0.081)**	**< 0.001**
		PA	−0.035 (0.077)	0.652
Multiple regression models	p factor	EC	**−0.478 (.044)**	**< 0.001**
		NA	**0.606 (0.039)**	**< 0.001**
		PA	**−0.179 (0.040)**	**< 0.001**
	Internalizing-specific	EC	**−0.141 (0.064)**	**0.027**
		NA	**0.806 (0.044)**	**< 0.001**
		PA	**−0.204 (0.056)**	**< 0.001**
	Externalizing-specific	EC	**−0.652 (0.081)**	**< 0.001**
		NA	0.052 (0.082)	0.529
		PA	−0.036 (0.070)	0.601

Note: NA=Negative affectivity; PA=Positive affectivity; EC=effortful control. Regressions controlled for overlapping temperament factors.

Table 2

Sample 2 Factor Correlations and Regressions Relating Associations between Latent Temperament Factors and Latent Dimensions of Child Psychopathology from Bifactor Modeling

Model	Psychopathology factor	Temperament factor	Beta (SE)	*p*
Individual correlation models	p factor	EC	**−0.586 (0.036)**	**< 0.001**
		NA	**0.545 (0.037)**	**< 0.001**
		PA	−0.060 (0.053)	0.262
	Internalizing-specific	EC	**0.179 (0.048)**	**< 0.001**
		NA	**0.110 (0.054)**	**0.042**
		PA	**−0.428 (0.086)**	**< 0.001**
	Externalizing-specific	EC	**−0.816 (0.089)**	**< 0.001**
		NA	**0.305 (0.096)**	**0.002**
		PA	−0.022 (0.071)	0.754
Multiple regression models	p factor	EC	**−0.584 (0.066)**	**< 0.001**
		NA	**0.220 (0.059)**	**< 0.001**
		PA	−0.021 (0.044)	0.603
	Internalizing-specific	EC	**0.648 (0.193)**	**0.001**
		NA	**0.382 (0.158)**	**0.015**
		PA	**−0.588 (0.084)**	**< 0.001**
	Externalizing-specific	EC	**−1.21 (0.041)**	**< 0.001**
		NA	**−0.378 (0.073)**	**< 0.001**
		PA	**0.169 (0.051)**	**0.001**

Note: NA=Negative affectivity; PA=Positive affectivity; EC=effortful control. Regressions controlled for overlapping temperament factors.