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Examining the etiological associations among higher-order temperament dimensions

Nicholas P. Allan [a,*], Amy J. Mikolajewski [a], Christopher J. Lonigan [a,b,*], Sara A. Hart [a,b], Jeanette Taylor [a]

[a] Department of Psychology, Florida State University, United States
[b] Florida Center for Reading Research, Florida State University, United States

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ABSTRACT

A multivariate independent pathway model was used to examine the shared and unique genetic and environmental influences of Positive Affect (PA), Negative Affect (NA), and effortful control (EC) in a sample of 686 twin pairs (*M* age = 10.07, *SD* = 1.74). There were common genetic influences and nonshared environmental influences shared across all three temperament dimensions and shared environmental influences in common to NA and EC. There were also significant independent genetic influences unique to PA and NA and significant independent shared environmental influences unique to PA. This study demonstrates that there are genetic and environmental influences that affect the covariance among temperament dimensions as well as unique genetic and environmental influences that influence the dimensions independently.

1. Introduction

Individual differences in the expression of various temperament traits play a substantial, yet complicated role in normal and abnormal development in childhood (e.g., Eisenberg, Fabes, Guthrie, & Reiser, 2000; Nigg, 2006; Rettew, Copeland, Stanger, & Hudziak, 2004). Behavioral genetics studies have been used to decompose the etiology of childhood temperament traits into their genetic and environmental components (e.g., Lemery-Chalfant, Doelger, & Goldsmith, 2008; Mullineaux, Deater-Deckard, Petrill, Thompson, & DeThorne, 2009). However, most of these studies only consider the genetic and environmental components unique to individual temperament traits and not the overlapping genetic and environmental components shared among traits. This study fills this gap in the literature by examining both the unique and shared etiological influences of core temperament dimensions in children.

Research on temperament is necessary because of the integral role of temperament in the development of adult personality as well as child and adult psychopathology (Nigg, 2006; Tackett, 2006). There is now considerable agreement that temperament and personality are highly overlapping constructs in children (e.g., Caspi & Shiner, 2006; De Pauw & Mervielde, 2010; Grist & McCord, 2010). Therefore, the transition from child temperament to adult personality does not concern the influence of temperament on the development of personality but rather concerns developmental continuity of temperament/personality (however, see Rothbart, 2011, for an opposing viewpoint). There is ample empirical evidence of an association between temperament traits and psychopathology (e.g., Eisenberg et al., 2005; Gjone & Stevenson, 1997; Leve, Kim, & Pears, 2005; Lonigan, Vasey, Phillips, & Hazen, 2004), as well as theoretical models that attempt to explain these relations between temperament/personality and psychopathology (e.g., vulnerability, pathoplasty models; Tackett, 2006). Understanding the etiological underpinnings of temperament may help clarify the developmental continuum of temperament/personality and the relations this construct shares with psychopathology.

1.1. The structure of temperament

Several different theoretical models have been developed to describe the structure and biological underpinnings of temperament (e.g., Buss & Plomin, 1984; Goldberg, 1990; Rothbart & Bates, 2006). Most models describe temperament hierarchically, consisting of at least three core dimensions at or near the top of the hierarchy. These include two reactive dimensions, Positive Affect (PA) and Negative Affect (NA), and a regulatory dimension, effortful control (EC; Mervielde, De Clercq, De Fruyt, & Van Leeuwen, 2005; Rothbart & Bates, 2006). The reactive dimension of PA is associated with approach behavior and the expression of positive emotions and is consistent with characteristics such as enthusiasm, pleasurable engagement, and sociability. The reactive dimension of NA is associated with withdrawal behavior and the expression of negative emotions and is consistent with characteristics such as nervousness,

* Corresponding authors. Address: Department of Psychology, Florida State University, 1107 West Call Street, Tallahassee, FL 32306-4301, United States.
E-mail addresses: allan@psy.fsu.edu (N.P. Allan), lonigan@psy.fsu.edu (C.J. Lonigan).

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anger, guilt, and sadness (Watson & Clark, 1984). The regulatory dimension of EC acts as a moderator of the reactive dimensions (Lonigan et al., 2004). This construct is associated with suppressing reactive behavior and emotions. High levels of EC are synonymous with high levels of attentional control (i.e., focusing and shifting attention; Derryberry & Reed, 2002). Further, EC is thought to be necessary for planning and goal-directed behavior (Caspi, Roberts, & Shiner, 2005; Nigg, 2006; Rothbart & Bates, 2006). These three dimensions of temperament have been consistently extracted in factor analytic studies involving children and adolescents, using both other- and self-report measures (Gartstein & Rothbart, 2003; Muris, Meesters, de Kanter, & Timmerman, 2005; Rothbart, Ahadi, Hershey, & Fisher, 2001; see Nigg, 2006; Putnam, Ellis, & Rothbart, 2001, for reviews). Further, these terms are highly overlapping with the terms extraversion (PA), neuroticism (NA), and conscientiousness (EC) that are used in personality research (De Pauw & Mervielde, 2010; Mervielde et al., 2005), so much so that for consistency and clarity, we use the term temperament when discussing either child temperament or child personality studies throughout the rest of the current study.

Whereas several theories of temperament operate under the assumption that the higher-order dimensions are orthogonal and have attempted to create measures reflecting this orthogonality (e.g., Costa & McCrae, 1985; Goldberg, 1992), evidence has accumulated that most temperament factors covary (e.g., Digman, 1997; Musek, 2007; Zawadzki & Strelau, 2010). For example, Musek (2007) examined correlations across the Big Five personality dimensions (e.g., extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience [openness]) in two adult and one adolescent Slovenian sample. In one of the adult samples and the adolescent sample, all of the dimensions were significantly correlated, with absolute values of correlations ranging from .17 to .54. In the other adult sample, most, but not all, dimensions were significantly correlated as well. Relevant to the focus on temperamental PA, NA, and EC in the current study, Musek found that extraversion and neuroticism were correlated at −.35, and conscientiousness (similar to EC) was correlated with extraversion at .36 and with neuroticism at −.37 in the adolescent sample. The overlap among temperament/personality traits has led several researchers to propose a hierarchical structure of temperament comprising two higher-order dimensions, labeled α, under which NA and EC as well as agreeableness are subsumed, and β, under which PA as well as openness are subsumed (e.g., Digman, 1997). Others have proposed the presence of a single higher-order factor of temperament/personality, labeled the general factor of personality (GFP; e.g., Musek, 2007; Rushton, Bons, & Hur, 2008). Support for both of these hierarchical models has been found using exploratory and confirmatory factor analysis (CFA) in adults as well as children and adolescents (e.g., Digman, 1997; Musek, 2007; Rushton et al., 2008; Wang, Chen, Petrill, & Deater-Deckard, 2013; Zawadzki & Strelau, 2010). Behavioral genetics studies focusing on the covariance between PA, NA, and EC can help refine temperament models by clarifying the nature of the genetic and environmental influences on this covariance.

1.2. Genetic and environmental influences on temperament

Twin studies can be used to identify the proportion of genetic and environmental influences associated with temperament dimensions. Additive genetic influences (or heritability, h^2) are those that children inherit from their parents. Shared environment influences include aspects of the environment that make twins more similar (c^2). Nonshared environment influences include environmental factors unique to each twin (as well as measurement error; e^2). These genetic and environmental influences are population statistics, providing information about sample-level variance and are therefore not specific to an individual.

Numerous twin studies have examined the univariate etiology of PA, NA, and EC in children and adolescents. Most studies, conducted across multiple measurement approaches, including self- and other-report, as well as direct assessment, report genetic estimates, in terms of proportions of phenotypic variance accounted for, ranging from around .20 to around .60 and nonshared environmental influences ranging from around .40 to around .80 (e.g., Anokhin, Golosheykin, Grant, & Heath, 2011; Goldsmith, Buss, & Lemery, 1997; Lemery-Chalfant et al., 2008; Mullineaux et al., 2009; Rettew et al., 2006; Spengler, Gottschling, & Spinath, 2012; see Saudino, 2005 for review). There is also mixed evidence of shared environmental influences for PA. For example, in a study using an actigraph to monitor activity level in a laboratory setting for 463 seven- to nine-year-old twin pairs, Wood, Saudino, Rogers, Asherson, and Kuntsi (2007) reported genetic effects of .36, shared environmental influences of .39, and nonshared environmental influences of .25. Isen, Baker, Raine, and Bezdjian (2009) examined the related trait of novelty seeking using a self-report measure in a sample of 605 nine- and ten-year-old twin pairs and found no genetic influences, shared environmental influences of .29, and nonshared environmental influences of .71. In contrast, there is little to no evidence of shared environmental influences in univariate studies of NA or EC. A study by Mullineaux et al. (2009) is one exception, as they found no genetic influences, a shared environmental influence of .57, and a nonshared environmental influence of .33 for father-reported temperament. In contrast, they found genetic estimates of .71, nonshared environmental estimates of .31 and no shared environmental estimates for mother-reported temperament. However, roughly half as many fathers completed questionnaires than did mothers (father-report was available for 98 twin pairs, mother-report was for 197 twin pairs). Further, the authors posited that rater bias may have accounted for discrepancies between mother- and father-report. Although they were unable to determine whether fathers' or mothers' ratings showed bias, mother-ratings of NA were more consistent with the values given in other studies than were father-ratings of NA.

Multivariate twin studies that include PA, NA, and EC in the same model provide a useful approach for exploring the levels of common and unique genetic, shared environmental, and nonshared environmental overlap among PA, NA, and EC, (Caspi et al., 2005; Saudino, 2005). However, only a few studies have moved beyond univariate twin study designs to examine the overlap among multiple temperament dimensions. Deater-Deckard, Petrill, and Thompson (2007) used a multivariate Cholesky decomposition model to examine the covariance between observer-rated lower-order traits subsumed under EC and NA (i.e., task persistence for EC and anger/frustration for NA) and parent- and teacher-rated conduct problems in a sample of 259 twin pairs (*M* age = 6.09 years, *SD* = .69). They reported a non-significant genetic correlation of .43 and a significant nonshared environmental correlation of .49 between task persistence and anger/frustration. Deater-Deckard et al. suggested that the non-significant genetic overlap was a function of the small sample size and not a lack of a genetic association between their measures of EC and NA. Gagne and Goldsmith (2010) examined the genetic and environmental influences between anger (a lower-order NA trait) at 12 and 36 months and lab-assessed EC at 36 months in a sample that ranged from 423 to 500 twin pairs. In a model containing lab-assessed anger, they reported no significant genetic overlap. A significant shared environmental correlation of −.73 was found between anger and EC at 36 months and a significant nonshared environmental correlation of .22 was found between anger at 12 months and EC at 36 months. In a model containing parent reports of children's anger, they found significant genetic correlations between EC at 36 months and anger at 12 ($r_g = -.26$) and 36 months ($r_g = -.56$), respectively. They also found a significant nonshared environmental correlation of .22 between EC and anger