Published in final edited form as:

J Abnorm Psychol. 2010 February ; 119(1): 186–196. doi:10.1037/a0017511.

A Person-Centered Personality Approach to Heterogeneity in Attention-Deficit/Hyperactivity Disorder (ADHD)

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Abstract

Person-centered personality approaches are an underutilized means of illuminating clinical heterogeneity of Attention-Deficit/Hyperactivity Disorder (ADHD). In this study, latent profile analysis was conducted with personality traits to identify homogeneous profiles within the ADHD population. Participants were 548 children ages six to 18 years (302 with ADHD). Personality traits were measured via parent report on the California Q-Sort. Latent profile analysis was conducted on the Big Five Factors. A six profile solution best fit the data. Resulting groups were characterized as “disagreeable,” “introverted,” “poor control,” “well-adjusted,” “extraverted,” and “perfectionistic.” External validation of this model using ADHD diagnosis, subtypes, and comorbid psychopathology suggested that children with ADHD could be parsed into four groups: 1) an introverted group with high rates of the ADHD-inattentive type, 2) a group characterized by poor control, with high rates of ADHD-combined type (ADHD-C) and comorbid disruptive behavior disorders, 3) an extraverted group, with ADHD-C and few associated comorbid disorders, and 4) possibly, a very rare “perfectionistic” group, exhibiting obsessive traits. A person-centered personality approach may be one promising way to capture homogeneous subgroups within the ADHD population.

Keywords

personality; ADHD; comorbidity; children; latent profile analysis

Attention-Deficit/Hyperactivity Disorder (ADHD), as defined by the DSM-IV-TR (APA, 2000), is characterized by behavioral symptoms of inattention, hyperactivity, and impulsivity. It is a common, chronic condition that is costly to children, families, and society (Pelham, Foster, & Robb, 2007). Although it is increasingly well-recognized that this syndrome captures a heterogeneous group of youngsters (Nigg, Willcutt, Doyle, & Sonuga-Barke, 2005), satisfying and valid means of describing that heterogeneity are lacking. The DSM-IV attempted to address this by designating three subtypes: primarily inattentive (ADHD-PI), primarily hyperactive-impulsive (ADHD-PHI), and combined type (ADHD-C). However, these subtypes have not yielded satisfying validation data (Lahey, Pelham, Loney, Lee, & Willcutt, 2005). For example, ADHD-PI may be composed of several different groups: for example, a group of hypoactive children and a group of children with a mild case of ADHD-C or subthreshold ADHD-C (Barkley, 2006; Carlson & Mann, 2002; Hartman, Willcutt, Rhee, & Pennington, 2004; McBurnett, Pfiffner, & Frick, 2001). Moreover, children with ADHD-C

vary with regard to whether they are aggressive/disruptive (Caspi et al., 2008; Jensen, Martin, & Cantwell, 1997; 2001).

Person-centered approaches, like latent class analysis (using binary predictors), latent profile analysis (using continuous predictors), and cluster analysis, may allow clinical population heterogeneity to be modeled. These statistical approaches enable disaggregation of data and decrease reliance on group statistics in favor of creating more homogeneous subgroups (Bergman, von Eye, & Magnusson, 2006; von Eye & Bergman, 2003). A series of papers has utilized a latent class analysis approach to ADHD symptoms with promising results in regard to redefining the clinical subtypes from DSM (Hudziak et al., 1998). Those studies suggest eight latent classes, six of which fall within the clinical range (Todd et al., 2008). Another approach that has been utilized in the personality literature, but not yet applied to ADHD, is to group youth by personality types. Applying a person-centered personality approach to ADHD can capitalize on an extant literature using person-centered personality approaches in children and adults (Robins & Tracy, 2003). It has the added theoretical advantage of enabling the literature on personality to inform what we know about ADHD. The mechanisms by which personality and psychopathology might be related range from the trivial (overlapping item sets; Lahey et al., 2008) to the crucial, such as that personality traits may be a predisposing element in causal pathways to psychopathology such as ADHD (Van Leeuwen, Mervielde, De Clercq, & De Fruyt, 2007; Watson, Kotov, & Gamez, 2006). As such, personality traits are an under-explored mechanism that may contribute to variation in ADHD symptoms. Elucidation of relations between personality and ADHD could inform knowledge of etiology and pathways to disorder.

The best way to conceptualize personality traits in children is a matter of disagreement in the field, with several trait-based personality and temperament models available (e.g., Eisenberg et al., 1996; Goldsmith et al., 1987; McCrae & Costa, 1987). One widely studied model, the Five Factor Model (McCrae & Costa, 1987), was selected for study here. Although developed using descriptors of adults, a substantial literature has suggested the model, sometimes with modifications, is useful in children (e.g., De Fruyt et al., 2006; Goldberg, 2001; Halverson et al., 2003; McCrae et al., 2000; Shiner, 1998; Shiner & Caspi, 2003). The validation of the Five Factor Model in children is based on elucidation of conceptual similarities between description of child temperament and adult personality factor (e.g., negative affect with neuroticism), as well as by empirical work utilizing factor analysis of parental and teacher ratings of children (Goldberg, 2001; Halverson et al., 2003; McCrae et al., 2000; as reviewed by Shiner, 1998; Shiner & Caspi, 2003). These data suggest that the basic trait structure is valid in children, although some caveats must be considered and are noted shortly.

In its standard adult form (McCrae & Costa, 1987), the Five Factor Model's major traits are Neuroticism (i.e., tendency to anxiety, depression, and other negative emotions, as well as difficulty coping with stress), Extraversion (i.e., interpersonal activity directed outward), Openness (i.e., active appreciation of life experiences), Agreeableness (i.e., altruism, trust, compliance, and concern, related to affiliation), and Conscientiousness (i.e., goal-directed behavior, organization, and impulse control). Although validated in a variety of age ranges (McCrae et al., 2002), the five factor structure may vary somewhat across developmental stages. For example, it is commonly noted that openness has not been as widely-validated in studies of children as it has in adults (Shiner & Caspi, 2003). As another example, John and colleagues (1994) found evidence of two additional factors, which they called irritability and positive activity, in a sample of adolescent boys. Nonetheless, the first four of the Five Factors remain heavily studied and reasonably well validated throughout development (Shiner, 1998; Shiner & Caspi, 2003). The Five Factor Model therefore forms one natural starting point for attempting to use personality to evaluate ADHD's heterogeneity.

Several of the Big Five traits have been related to aspects of ADHD already. Compared with typically developing individuals, those with ADHD have been characterized by lower levels of conscientiousness and agreeableness and higher levels of neuroticism (Miller, Miller, Newcorn, & Halperin, 2008; Nigg et al., 2002). In addition, some studies have found relations between ADHD and higher levels of extraversion (Parker, Majeski, & Collin, 2004), although this appears to depend on how ADHD is measured and possibly on gender (Nigg et al. 2002). When evaluating the relations among ADHD and traits, it is important to recognize that ADHD symptoms fall into two correlated domains: inattention-disorganization and hyperactivity-impulsivity. Specific relations between these ADHD symptom domains and personality traits have been found as well. Inattention has been associated with low conscientiousness, while hyperactivity-impulsivity has been associated with low agreeableness and, in some cases, high extraversion (Nigg et al., 2002; Nigg, Goldsmith, & Sachek, 2004). Developmental differences in the relationship between personality and ADHD have been suggested. Childhood ADHD is associated with low levels of conscientiousness (Martel & Nigg, 2006), while ADHD that persists into adulthood appears to be associated with neuroticism and lower agreeableness (Miller et al., 2008).

As alluded to earlier, ADHD's heterogeneity also includes its comorbid clinical picture. The most common comorbid problems are in the domain of disruptive behavior, including oppositional, conduct, and aggressive behaviors. This type of heterogeneity, while obviously important to ADHD taxonomy, need not be sacrificed in a personality approach. Personality traits also have been associated with these co-occurring problems. For example, when statistically controlling for overlap with other disruptive behaviors, inattentive ADHD symptoms were related to lower effortful forms of control like conscientiousness, while oppositional-defiance was related to higher negative emotionality like neuroticism (Martel & Nigg, 2006; Nigg et al., 2002).

In addition to aggression and conduct problems, anxiety and mood disorders must be considered. Once again, a personality perspective may provide a parsimonious means of identifying subgroups of children with such symptoms, but with more sensitivity than an approach relying on classification of disorders (which can vary above and below threshold cut points). Negative affect (i.e., neuroticism) and low positive affect (likely related to low extraversion) exhibit prominent relations with anxiety and mood disorders. Whereas negative affect appears to be a liability factor for anxiety and mood disorders, low positive affect appears to be a specific liability factor for depressive disorders (Clark, 2005; Kotov, Watson, Robles, & Schmidt, 2007). This model generally holds in adults and children, although more validation of the model in children is needed (Anderson & Hope, 2008).

Nigg et al. (2004) proposed a multi-pathway conception of ADHD that takes into account early personality antecedents and personality correlates. Working from what is known about neural correlates of ADHD and of personality and temperament, they suggested that ADHD could develop via (a) high approach or high extraversion, (b) low control or impulsivity, or (c) mood dysregulation. They also speculated that some youth are exuberant (Kagan, Snidman, & Arcus, 1998), but otherwise not impaired neurologically, whereas others may have extreme personality traits reflecting underlying dysfunction in regulatory traits. With regard to comorbid profiles, integrated paths were hypothesized. For example, they suggested that conscientiousness is specifically related to ADHD, whereas negative affect and neuroticism may be associated with ADHD due to its overlap with disruptive behaviors like Oppositional-Defiant Disorder (ODD) and Conduct Disorder (CD; Nigg et al., 2002; Nigg et al., 2004). Further, personality traits may not only elucidate these patterns of psychopathology in children, but may shed light on the mechanism by which certain constellations of psychopathology are preferentially transmitted within families across generations. Therefore, the personality types

that characterize children with ADHD also may exhibit specific relations with parental psychopathology and parent personality.

The present study builds on these ideas, while moving from a variable centered approach to a person-centered approach. No work to date has examined whether profiles of personality traits can shed light on individual differences in ADHD symptoms. This can be ideally done using a sample that includes those with low levels of symptoms and yet richly encompassing the clinical end of the spectrum by including an oversampling of cases. To this end, the study first identified a latent profile solution using personality traits to evaluate the hypothesis that the ADHD group (vs. the control group) would be composed of at least three groups of children: those with low control, those with high approach (i.e., high extraversion and low agreeableness), and those with high negative emotionality (Nigg et al., 2004). The resultant profiles were subsequently evaluated (in the same sample) in relation to ADHD symptoms, DSM-IV ADHD subtypes, and comorbid psychopathology. As a secondary step, the profiles were examined in relation to parent psychopathology and parent personality traits.

METHOD

Participants

Overview—Participants were 548 children (321 boys) between the ages of six and 18 years. As shown in Table 1, children were initially assigned using DSM-IV criteria to one of two groups: ADHD ($n=302$) and non-ADHD comparison youth (“controls,” $n=199$). Forty-seven additional children who were classified as having situational or sub-threshold ADHD (did not meet criteria for either ADHD or control group as explained below), were included to provide more complete coverage of the dimensional trait space of both personality and ADHD (Levy, Hay, McStephen, Wood, & Waldman, 1997; Sherman, Iancono, & McGue, 1997). Using a DSM-IV perspective, the ADHD group included 143 ADHD-Combined type (ADHD-C) and 72 ADHD-Predominantly Inattentive type (ADHD-PI) who had never in the past met criteria for ADHD-C, based on parent report. All youth assigned an ADHD diagnosis met DSM-IV criteria for duration, impairment, and onset as ascertained by the structured interviews described later. The current sample included no children with the hyperactive-impulsive ADHD subtype, similar to other clinical samples of children with ADHD (e.g., Shaw et al., 2007). As shown in Table 1, 161 children met DSM-IV criteria for Oppositional-Defiant Disorder (ODD), 19 for Conduct Disorder (CD), 41 for Major Depressive Disorder (lifetime), 13 for Dysthymia (lifetime), and 45 for Generalized Anxiety Disorder (lifetime). Thus, the children represented a typical range of comorbid disorders seen in samples of children with ADHD. Children came from 468 families; 388 families had one child in the study, and 80 families had two children in the study.

Recruitment and Identification—A broad community-based recruitment strategy was used, with mass mailings to parents in local school districts, public advertisements, and fliers at local clinics, in an effort to mimic the recruitment strategy of the MTA study (Arnold et al., 1997). Families initially recruited then passed through a standard multi-gate screening process to establish diagnostic groupings. At Stage 1, all families were screened by phone to rule out youth prescribed long-acting psychotropic medication (e.g. antidepressants), neurological impairments, seizure history, head injury with loss of consciousness, other major medical conditions, or a prior diagnosis of mental retardation or autistic disorder, as reported by the parent.

At Stage 2, parents and teachers of remaining eligible youth completed the following standardized rating scales: Child Behavior Checklist / Teacher Report Form (CBCL/TRF; Achenbach, 1991), Conners Rating Scales-Revised, (Conners, 1997), and the ADHD Rating Scale (ADHD-RS; DuPaul, Power, Anastopolous, & Reid, 1998). In addition, parents

completed a structured clinical interview to ascertain clinical symptom presence, duration, and impairment. Children also completed IQ and achievement testing. Families were screened out if they failed to attend the diagnostic visit.

The diagnostic interview used was dependant on the year of data collection. For participants who participated between 1997 and 2001 ($N=218$), the Diagnostic Interview Schedule for Children (*DISC-IV*; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000) was completed with the parent by telephone or during on-campus visits. A trained interviewer (a graduate student or advanced undergraduate with at least ten hours of training) administered the *DISC-IV*. Fidelity to interview procedure was checked by having the interview recorded with five percent reviewed by a certified trainer. For children who were administered the *DISC-IV* and met duration, onset, and impairment criteria for *DSM-IV*, an “or” algorithm was used to establish the diagnostic group and to create the symptom count. Teacher-reported symptoms on the *ADHD-RS* (that is, items rated as a “2” or “3” on the 0 to 3 scale) could be added to the parent-endorsed symptom total, up to a maximum of two additional symptoms, to get the total number of symptoms (Lahey et al., 1994). Children failing to meet cut-offs for all parent and teacher *ADHD* rating scales at the 80th percentile and having four or fewer symptoms of *ADHD* with the “or” algorithm were considered non-*ADHD* controls.

For participants who participated between 2002 and 2008, youth and their primary caregiver completed the Kiddie Schedule for Affective Disorders and Schizophrenia (*KSADS-E*; Puig-Antich & Ryan, 1986). The data from the interviews and parent and teacher rating scales were presented to a clinical diagnostic team consisting of a board certified child psychiatrist and licensed clinical child psychologist. The clinical diagnostic team could use the same “or” algorithm in their diagnostic decision making if evidence of impairing symptoms in two settings was present. Their agreement rates were acceptable for *ADHD* diagnosis, subtypes, and current *ODD* and *CD* (all kappas $\geq .89$).

Pooling the data across families that received the *KSADS* and the *DISC* was justified based on our analysis of agreement between the two methods in 430 youth for whom a parent completed both a *KSADS* and a *DISC*. The two interviews agreed adequately for total number of symptoms (inattention, $ICC=.88$; hyperactivity, $ICC=.86$), presence of six or more symptoms of *ADHD* ($kappa=.79$), presence of impairment ($kappa=.64$), and presence of *ADHD* (defined as six or more symptoms + cross situational impairment, for purposes of computing agreement; $kappa=.79$).

Comorbid Child Diagnoses—The structured diagnostic interview was used for establishing the presence of *ODD*, *CD*, anxiety disorders, and depressive disorders based on *DSM-IV* criteria. Convergence of these diagnoses across interview methods was not assessed.

Measures

All youth attended a second laboratory visit a few weeks later during which time parents completed Q-sort personality ratings. A four-subtest short form of the *WISC-III* (data collection was begun prior to publication of the *WISC-IV*) was administered; estimated full scale IQ over 75 was required for inclusion.

Child Psychopathology—LCA-derived profiles were compared on psychopathology using structured interview diagnoses as described above, as well as using scales of the *ADHD* Rating Scale and the Child Behavior Checklist (CBCL).

Child Personality Traits: California Q-Sort—Parents completed the California Child Q-Sort (CCQ), specifically the common language version (Caspi et al., 1992). They were instructed to complete their ratings based on their child's behavior off of medication (if

applicable). The CCQ is a typical Q-Sort consisting of 100 cards which were to be placed in a forced-choice, nine-category, rectangular distribution. The rater described the child by placing descriptive cards in one of the categories, ranging from one (least descriptive) to nine (most descriptive). Instructions were derived from the standard instruction set provided by Jack Block (personal communication to J. Nigg, 1996). To measure the Big Five Factors, scales developed by John et al. (1994) were used. A composite score was generated by reverse-scoring selected items and taking a mean, with scores ranging from one to nine. Scale reliabilities were all above .7 with the exception of the scale for openness ($\alpha=.56$).

Parent Psychopathology: Symptom Checklist-90 (SCL-90) and Conners Adult ADHD Rating Scales (CAARS)—Parents completed a self-report version of a subset of questions from the SCL-90 (Derogatis, 1994) in order to assess anxiety and mood problems. The SCL-90 consists of 90 items which measure psychological distress, including anxiety and depression. Items are rated on a five-point scale, ranging from 0 (not at all) to 4 (extremely). The SCL-90 demonstrates adequate reliability, and construct validity is satisfactory. In the current study, 23 items pertaining to anxiety and depression were administered. Since the individual anxiety and depression scales were reliable (both α above .9) and demonstrated a high, significant correlation ($r=.79$, $p<.01$), a composite anxiety/depression scale was generated to simplify the results. This composite demonstrated adequate internal reliability ($\alpha=.95$). To assess externalizing problems, parents also completed a self-report Conners Adult ADHD Rating Scale (CAARS; Conners, Erhardt, & Sparrow, 1999), a nationally-normed, well-validated self-report rating scale assessing ADHD symptoms, impulsivity, mood lability, and aggression. The scales demonstrated satisfactory internal consistency, inter-rater reliability, and predictive power (Adler et al., 2007). The ADHD Index score was utilized in the current study as a summary measure of ADHD-like symptoms in parents. It had adequate internal reliability ($\alpha=.86$).

Parent Personality Traits: NEO Five Factor Inventory (NEO-FFI)—Parents completed a self-report version of the NEO-FFI that contained 60 items (Costa & McCrae, 1992). The five scales each included 12 items and had adequate internal consistency, temporal stability, and construct validity. In the current study, alpha reliabilities ranged from .68 to .84.

Data Analysis

Latent profile analysis was conducted using the Mplus software package (Muthen & Muthen, 2007). The Mplus software package allows for the statistical control of nonnormality and outliers through the use of robust maximum likelihood estimation (Curran, West, & Finch, 1996). Missingness was minimal in the current study: no personality data were missing, whereas five percent of clinical data were missing. Therefore, full information likelihood estimation (i.e., FIML or direct fitting), a method of directly fitting models to raw data without imputing values (McCartney, Burchinal, & Bub, 2006), was utilized to address this missingness. The presence of siblings and the resulting non-independence of data points was addressed using the clustering feature of Mplus. This clustering feature takes into account the non-independence of the data when computing test statistics and significance tests.

Latent profile analysis model fit was compared using log-likelihood, Akaike information criteria (AIC), Bayes information criteria (BIC), and entropy, as is recommended in evaluating these kinds of models (Grant et al., 2006). Smaller values of log-likelihood, AIC, and BIC indicate better fit to the data or increased probability of replication, and higher values of entropy reflect better distinctions between groups (Kline, 2005). Because some evidence suggests that the BIC performs best of the information criterion indices (Nylund, Asparouhov, & Muthen, 2007), BIC was prioritized in interpreting the current data. The current study sought to maximize separation between groups (entropy), while also maximizing the generalizability of

the model (BIC), based on other previous work using latent profile analysis (e.g., Vaughn, Perron, & Howard, 2007). Thus, an a priori rule was established in which the model with the lowest BIC and highest entropy would be considered to have the best fit. Method validation of the best fitting solution was conducted using cluster analysis in SPSS. External validation of the best-fitting profile solution vis a vis comorbid psychopathology was conducted using multivariate analysis of variance, followed by corrected posthoc analyses.

Data Analytic Checks—Since item overlap between personality and symptom scales could affect results, item overlap between personality scales and ADHD symptoms were evaluated by independent judges based on conceptual similarity of items (see Martel & Nigg, 2006 for more information). Three items were removed from the scale for conscientiousness and two items were removed from the scale for extraversion based on their overlap with ADHD symptoms. Reliability remained acceptable ($\alpha=.74$ for extraversion and .77 for conscientiousness). Results were checked using these nonoverlapping scales. Results were also checked with teacher ratings of child behaviors. Finally, possible age and gender effects were examined.

RESULTS

Descriptive Statistics

Descriptive statistics on the sample are displayed in Table 1. The ADHD group had more boys and was younger than the non-ADHD comparison group. As expected, children with ADHD exhibited higher levels of neuroticism and extraversion and lower levels of agreeableness and conscientiousness than children without ADHD. These mean differences between groups were considered to be meaningful for subsequent profile-based analyses.

Latent Profile Analysis

In order to identify the best-fitting model, latent profile models containing one through seven profiles were fit to exhaust the available models. Eight-profile models (and above) would not converge and were judged unsuitable to the data. Fit parameters for the models with one through seven profiles are displayed in Table 2. As shown, significant improvements in fit (measured using AIC, BIC, log-likelihood, and entropy) occurred as the number of profiles increased up to six profiles, with a drop-off in entropy at the seven-profile model. Thus, the six-profile model exhibited the highest entropy statistic while exhibiting a lower BIC than every other model except the seven-profile model, meeting the a priori rule of highest entropy combined with lowest BIC.

Although the six-profile model appeared to provide the best fit to the data, it was noted that two profiles contained only a handful of individuals and therefore are difficult to evaluate. Descriptive statistics for personality traits within each profile for each solution are shown in Table 3 and are depicted graphically in Figure 1. As shown in Table 3 and Figure 1, the first profile exhibited low mean levels of agreeableness and was described as “disagreeable.” This profile contained five individuals and was only evident in the six-profile (and seven-profile) solution; thus, this profile seemed to be less robust than the other profiles. The second profile exhibited moderate levels of all traits with relatively low levels of extraversion and might be described as “introverted.” The third profile exhibited low levels of conscientiousness and might be characterized by “poor control.” The fourth profile, which might be described as “well-adjusted,” was characterized by low levels of neuroticism and relatively high levels of agreeableness. The fifth “extraverted,” or high approach, profile was characterized by high extraversion. The sixth profile, which might be described as obsessive or “perfectionistic,” was a group of seven individuals characterized by high neuroticism, openness, and conscientiousness. Although it only had seven individuals, this profile (always with the same

seven individuals in it) appeared in all solutions. These six profiles were retained for initial external validation with diagnostic variables in the same sample.

Control for Overlap Between Personality Traits and ADHD Symptoms—Latent profile analysis results were checked after controlling for items that overlapped between personality traits and ADHD symptoms (as described in the Methods). Latent profile analysis was conducted again following item removal. Again, the six-profile solution demonstrated the best fit. Correspondence between the profiles generated from the solution with item overlap removed demonstrated satisfactory correspondence with the original six-profile solution ($\kappa = .70, p < .01$).

Age and Sex Effects—Age and sex were separately checked as covariates in latent profile analyses in order to examine their significance as predictors of latent profile membership. Neither age nor sex were significant predictors of latent profile membership (all $p > .05$), suggesting they did not significantly moderate latent profile membership.

Method Validation of Latent Profile Analysis Classification

K-means cluster analysis was conducted in order to evaluate the extent to which the six-profile solution generated by latent profile analysis could be replicated by a second method. The six-profile solution generated by cluster analysis exhibited significant, but relatively low, correspondence with the six-profile solution generated by latent profile analysis ($\kappa = .17, p < .01$). Although four of the six clusters exhibited almost perfect convergence across methods, the “disagreeable” and “low control” groups exhibited low convergence across methods. When external correlates of “disagreeable” and “low control” latent profiles and clusters were examined, the primary differences between the respective profiles and clusters were that there were many more individuals in the “disagreeable” cluster compared to the “disagreeable” profile, and a substantial proportion of individuals in the “disagreeable” cluster met criteria for ADHD, compared to the “disagreeable” profile, where few individuals met criteria for ADHD.

External Validation of Latent Profiles

The latent profile scores were saved for each individual child, and then children were placed in groups based on their profile assignment. These groups were then compared with regard to DSM-IV ADHD diagnosis, subtypes, other diagnoses comorbid with ADHD, and other forms of psychopathology. They were also compared with regard to parent personality and parent psychopathology.

It was notable that the personality groups significantly differed in sex ($X^2[5] = 253.49, p < .01$). There was a relatively higher percentage of girls (compared to boys) in the “introverted” (46%), “well-adjusted” (55%), and “perfectionistic” (43%) groups compared to the other groups (all 40% or below).

As shown in Table 4, the personality profiles significantly differed in ADHD diagnosis ($X^2[5] = 253.49, p < .01$), ADHD subtypes ($F[5] = 7.05, p < .01; \eta^2 = .14$), psychopathology comorbid with ADHD ($F[15, 1491.1] = 10.99, p < .01; \eta^2 = .09$), and other disruptive and anxiety/mood psychopathology ($F[25, 1632.32] = 4.7, p < .01; \eta^2 = .05$). The “introverted,” “poor control,” “extraverted,” and “perfectionistic” groups all included a majority of children with ADHD and thus appeared to have promise as “types” of ADHD. The other two “well-adjusted” and “disagreeable” groups tended to be mostly non-ADHD children. Children in the “poor control” group experienced the highest level of other psychopathology, including both disruptive behavior disorders and anxiety/mood disorders. Children in the “extraverted” group also experienced elevated comorbid psychopathology, although not as high as those in the low control group. The “perfectionistic” group experienced relatively high levels of depressive

disorders, and the “disagreeable” group tended to have disruptive behavior disorders without ADHD.

As shown in Table 4, the personality profiles significantly differed in inattention and hyperactive-impulsive ADHD symptoms, as rated by either parent ($F[10, 834]=41.13$, $p<.01$; $\eta^2=.33$) or teachers ($F[10,826]=22.71$, $p<.01$; $\eta^2=.22$). Parent and teacher report of symptoms both indicated that the “introverted,” “low control,” and “extraverted” groups experienced high levels of inattentive symptoms compared to the “well-adjusted” group, and the “low control” and “extraverted” groups experienced high levels of hyperactive-impulsive symptoms compared to the “well-adjusted” and “introverted” groups (post hoc comparison $p<.05$ with Tukey correction). The personality profiles also significantly differed in other dimensional forms of psychopathology, such as anxiety/depression, withdrawal/depression, attention problems, and aggressive behavior ($F[20,1216]=16.05$, $p<.01$; $\eta^2=.21$). As shown in Table 4 and indicated by post hoc Tukey tests, anxiety/depression was evident in the “low control” groups, withdrawal/depression in the “disagreeable” group, attention problems in the “low control” group, and aggressive behavior in the “low control” and “extraverted” groups.

Child personality profiles were then examined in relation to parent psychopathology and parent personality. They differed in parent psychopathology, measured by the CAARS and the SCL-90 ($F[10,614]=2.91$, $p<.01$; $\eta^2=.05$). As shown in Table 4, parents of the children in the “low control” and “extraverted” groups had higher ADHD symptomatology compared to the “introverted” and “well-adjusted” groups ($p>.05$ in post hoc analyses), and parents of children in the “low control” group had higher levels of depression compared to the “well-adjusted” group ($p<.05$).

The child types also exhibited significant differences in parent personality on the omnibus MANOVA ($F[25,2005]=3.19$, $p<.01$; $\eta^2=.04$; shown in Table 4). Post hoc tests confirmed that parents of children in the “low control” group exhibited higher levels of self-rated neuroticism and lower levels of self-rated agreeableness than the other groups ($p<.05$). Parents of children in the “low control” and “extraverted” groups exhibited lower levels of self-reported conscientiousness.

Overall, children with ADHD appeared divided into four meaningful groups. First, an “introverted” group tended to meet criteria for the inattentive subtype of ADHD with few symptoms of hyperactivity-impulsivity. The combined subtype of ADHD appeared to divide into two subgroups: an “extraverted” group and a “poor control” group. The “extraverted,” or high approach, group tended to meet criteria for the combined type of ADHD, but only a minority had disruptive behavior comorbidity (32%). The “poor control” group, defined in personality terms by very low conscientiousness, tended to meet criteria for the combined subtype of ADHD, but a majority also had ODD and associated disruptive behavior (61%), and they also exhibited significant anxiety/mood problems. Finally, there was a very small “perfectionistic” group. The two remaining groups divided up the typically developing or “non-ADHD control” group. The small “disagreeable” group (group 1) tended to have ODD, but not ADHD. The larger “well-adjusted” group exhibited low levels of ADHD and other psychopathology, as did their parents.

DISCUSSION

Several efforts have been made in recent years to better capture ADHD heterogeneity with empirical data using latent class analysis with DSM-IV symptoms. In the current study, a person-centered approach based on personality traits was utilized in an effort to identify more homogeneous latent profiles of ADHD. Similar to prior work in this area (e.g., Acosta et al., 2008; Todd et al., 2008) and in line with study hypotheses of multiple pathways to ADHD

(Nigg et al., 2004), we found at least three clinically meaningful subgroups of ADHD. These included a group characterized by low extraversion, a group with high extraversion, and a more disturbed group with low control. We also found evidence of an unexpected rare group of youngsters with ADHD and obsessive or perfectionistic traits. Although this last group deserves further study, these four groups exhibited salient differences in regard to ADHD subtypes, profile of comorbid disorders, and parent personality and psychopathology that may be clinically meaningful. Further, these subgroups provide a reasonable fit to prior multiple pathway models of ADHD (Nigg et al., 2004), but also suggest some modifications to that model.

The introverted group tended to include individuals (including a relatively higher percentage of girls) with the inattentive subtype of ADHD, with few hyperactive-impulsive symptoms. About half of the inattentive type (43%) was classified in this group. This group may be related to those individuals characterized by inattention and inconsistent alertness (Hartman et al., 2004; McBurnett, Pfiffner, & Frick, 2001), possibly related to the non-hyperactive inattentive groups found in latent class analyses of ADHD (Todd et al., 2008). The DSM-IV inattentive type classification may include subthreshold ADHD-C, as well as youth with a true “inattentive-only” type of syndrome (Stawicki, Nigg, & von Eye, 2006). It may be that the introverted profile identified here captures that elusive group of youngsters who have a different type of ADHD with mainly inattentive and withdrawn features. It will be of interest to determine in future work whether this group, which had a higher proportion of girls than the other groups, would be at elevated risk (versus the other groups) of developing depression during adolescence and early adulthood.

The combined subtype of ADHD also appeared heterogeneous from a personality perspective; it appeared to subdivide into two clinically meaningful groups. The extraverted group tended to have ADHD-C (with a small percentage of ADHD-PI; presumably those “subthreshold” cases just referenced), but only a minority had comorbid disruptive behavior (32%) or anxiety or mood problems (16%). Likewise, the parents of children in this group exhibited a personality profile characterized by low conscientiousness, but no severe parent psychopathology aside from ADHD. These youth therefore may have been relatively well adjusted ADHD youth, perhaps tending toward the “exuberant” youngsters referred to by Kagan et al. (1998) who appear to be impulsive, active, and energetic, but may not have severe psychopathology aside from ADHD. This group could also be a “high approach” type of ADHD as suggested by Sonuga-Barke (2005). Nigg et al (2004) has noted that there may not be a clear neuropsychological dysfunction in this subgroup of children. Thus, it would be of interest in future work to determine whether this is a group with more intact executive and neuropsychological function while still meeting criteria for ADHD.

In contrast, the “impulsive” group characterized by poor control included many of the youth with ADHD-C (with a small number of those with ADHD-PI). Nearly all these children (92.5%) had either a disruptive behavior or anxiety/mood disorder. A majority of these children had ODD (61%) or associated disruptive behavior problems. Parents of these children also exhibited a severe profile characterized by high neuroticism, low agreeableness, low conscientiousness, high ADHD symptoms, and high depression. The impulsive group appears characterized by generalized, comorbid disruptive behavior problems and severe clinical psychopathology (Connor & Doerfler, 2008). Thus, they might have a case of “complicated” ADHD as opposed to the “simple” ADHD of the extraverted group. Since conscientiousness is an effortful form of control (Nigg, 2000) believed to reflect the integrity of the frontal cortex and frontal-striatal connections, as well as intact dopaminergic and serotonergic innervation (Depue & Lenzenweger, 2006; Dragan & Oniszczenko, 2007; Sonuga-Barke, 2005; Whittle, Allen, Lubman, & Yucel, 2006), this might explain the broad and severe manifestations of this kind of personality risk. Thus, the results provide some support for the idea that there is a

meaningful difference between two types of ADHD-C. The course of illness in the “extraverted” and “impulsive” groups would be of considerable interest.

These results are in line in many respects with the multiple pathway temperament model that guided the study (Nigg et al., 2004). That model posited at least three primary personality pathways to ADHD: low control, high approach, and high negative emotionality/anger. The low control and high approach groups appear supported here. The angry group posited by Nigg et al. (2004) did not appear and instead appeared to fold into the impulsive group. The third group appeared instead as a group with low positive affect or low extraversion, and was probably best characterized in terms of low approach, along with high levels of inattention. More generally, the findings are consistent with previous work using variable-centered data analysis examining the relationship between personality traits and externalizing psychopathology (Lynam et al., 2005; Martel & Nigg, 2006; Miller et al., 2008; Nigg et al., 2002; Nigg et al., 2004; Parker, Majeski, & Collin, 2004). For example, low levels of conscientiousness and high levels of extraversion were related to ADHD and other disruptive behavior disorders like ODD and CD.

In sum, heterogeneity within the ADHD population may be clarified by utilization of personality trait profiles. More homogenous subgroups of ADHD may be able to be identified using a personality perspective. In particular, one large group appears to be characterized by high extraversion; another smaller group appears to exhibit low control and a tendency to experience severe disruptive behaviors, along with ADHD. Another group has low levels of extraversion and appears to exhibit a predisposition to inattention. Although the latent profiles were largely replicated using K-means cluster analysis, there appeared to be somewhat less consistency across the low control and disagreeable groups using this approach, suggesting that the distinctions between these two groups may vary somewhat based on the choice of classification technique.

These groupings have implications for future work. First, they may suggest more homogenous subgroups within ADHD that may exhibit commonalities in other risk factors or outcomes. Therefore, diagnostic subtyping efforts based on personality traits may be useful since they may be purer phenotypes. These purer phenotypes may, in turn, map better onto comorbid presentations of ADHD which have an impact on treatment effectiveness and outcome (Jensen et al., 2001). Since age was not a significant predictor of the latent profiles, these personality profiles may be consistent over time, suggesting they may have utility as somewhat static indicators of developmental course and prognosis of disorder. Second, and more speculatively, individual differences in psychological functioning may be able to be viewed as a product of each individual's unique constellation of personality traits. That profile can trigger research hypotheses related to multifactorial genetic profile and its interactions with environmental inputs. From that perspective, using personality traits to characterize subgroups may enable literature on the genetics and neurobiology of personality to be brought to bear in future studies.

Several limitations of these conclusions should be noted. The current study utilized personality measures completed by parents, although external validation of personality profiles held even when using teacher ratings of ADHD, suggesting that results are not due to shared method variance. Future work might utilize ratings by multiple caregivers, teachers, and/or peers, as well as observational measures. Limited literature on the correspondence of ratings of children's personality made by different individuals suggest that correlations are moderate (Putnam & Rothbart, 2006). In addition, data used in the current study were cross-sectional. Therefore, developmental relations between personality and ADHD were not addressed. It is quite possible that those influences are bidirectional (Nigg, 2006; Watson, Kotov, & Gamez, 2006). Although age was not a significant predictor of latent profiles in the current study, age and sex effects deserve more attention in future work on personality types of ADHD.

Summary

The phenotypic heterogeneity of ADHD was examined using a person-centered latent profile analysis approach. Latent profiles were identified based on the Big Five Factors, and these profiles were differentially related to ADHD and comorbid psychopathology. At least three major subgroups of children with ADHD were able to be meaningfully distinguished based on personality traits. The three main subgroups were characterized by introversion, low control, and extraversion. These groupings were meaningful in relation to ADHD symptomatology, comorbid psychopathology, parent psychopathology, and parent personality. The current inattentive type was classified mainly into an introverted group. The ADHD combined type was divided between a mildly disturbed extraverted group and a severely disturbed impulsive (low conscientiousness) group. The heterogeneity of ADHD thus appears to be able to be parsed meaningfully with personality traits.

Acknowledgments

This research was supported by NIH National Institute of Mental Health Grant R01-MH63146, MH59105, and MH70542 to Joel Nigg. Martel was supported by NIH F31 MH075533. We are indebted to the families and staff who made this study possible.

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Figure 1.
Six-Profile Solution for Big Five Factors

Table 1

Descriptive Statistics on Sample

	ADHD <i>n</i> =302	Control <i>n</i> =199	Total <i>N</i> =548 ^{<i>I</i>}
Boys <i>n</i> (%)	204(67.5)	96(48.2)	321(58.6)**
Ethnic Minority <i>n</i> (%)	78(25.8)	54(27.1)	144(26.3)
Age	11.32(2.93)	12.5(3.24)	11.67(3.06)**
IQ	110.33(14.92)	103.78(13.90)	106.2(14.7)**
Family Income	62643.64(67080.22)	75244.72(51109.84)	66694.67(59532.75)*
ADHD-C <i>n</i> (%)	143(47.4)	--	143 (47.4)**
ADHD-PI <i>n</i> (%)	72(23.8)	--	72(23.8)**
ODD <i>n</i> (%)	118(39.1)	26(13.1)	161(29.4)**
CD <i>n</i> (%)	18(6)	1(.5)	19(3.5)**
MDD <i>n</i> (%)	28(9.3)	9(4.5)	41(7.5) ⁺
Dysthymia <i>n</i> (%)	9(3)	2(1)	13(2.4)
GAD <i>n</i> (%)	29(9.6)	11(5.5)	45(8.2)
Neuroticism	4.62(1.19)	3.74(1.09)	4.28(1.23)**
Extraversion	5.98(1.43)	5.43(1.31)	5.75(1.41)**
Openness	6.05(1.2)	5.94(1.11)	5.99(1.19)
Agreeableness	5.86(1.3)	6.75(1.01)	6.19(1.28)**
Conscientiousness	3.99(1.24)	6.39(1.18)	4.92(1.69)**

via t-tests or chi-squares. ADHD-C=ADHD combined subtype. ADHD-PI=ADHD, predominantly inattentive subtype. ODD=Oppositional-Defiant Disorder. CD=Conduct Disorder. MDD=Major Depressive Disorder. GAD=Generalized Anxiety Disorder.

⁺ Note. $p < .10$.

* $p < .05$.

** $p < .01$

^{*I*} =Forty-seven children were identified as having situational ADHD or were screened out of the study at a later point in time, but were included in study analyses because they had data on traits and comorbid psychopathology.

Table 2

Latent Profile Analysis Fit Indices

	Loglikelihood	AIC	BIC	entropy
1-profile	-4726.64	9473.27	9516.37	
2-profile	-4602.85	9237.69	9306.65	.72
3-profile	-4521.81	9087.62	9182.44	.83
4-profile	-4466.63	8989.25	9109.93	.78
5-profile	-4431.48	8930.95	9077.49	.81
6-profile	-4409.66	8899.32	9071.72	.83
7-profile	-4381.72	8855.45	9053.70	.80

Table 3

Latent Profile Solutions using Five Factors: Descriptive Statistics

		N	E	O	A	C	ADHD%
<u>Two-Profile Solution</u>							
profile 1	202	4.89	5.9	5.81	5.05	3.51	55
profile 2	346	3.91	5.66	6.1	6.89	5.78	45
<u>Three-Profile Solution</u>							
profile 1	267	3.62	5.64	5.97	6.88	6.13	24.2
profile 2	274	4.84	5.9	5.93	5.5	3.62	74.5
profile 3	7	8.2	4.56	9	6.54	9	1.3
<u>Four-Profile Solution</u>							
profile 1	210	4.11	6.43	6.28	5.82	3.98	56.6
profile 2	107	5.76	5.04	5.47	5.39	6.41	28.1
profile 3	224	3.59	5.52	5.89	6.92	6.41	13.9
profile 4	7	8.2	4.56	9	6.54	9	1.3
<u>Five-Profile Solution</u>							
profile 1	40	4.98	4.04	5.01	6.53	5.5	6.6
profile 2	189	3.4	5.67	6	6.94	6.58	8.9
profile 3	103	5.84	5.38	5.6	5.34	3.15	27.5
profile 4	7	8.2	4.56	9	6.54	9	1.3
profile 5	209	4.02	6.42	6.29	5.86	4.02	55.6
<u>Six-Profile Solution</u>							
profile 1	5	5.36	3.61	4.16	3.51	6.68	.3
profile 2	45	5.33	3.9	5.78	6.87	4.44	9.9
profile 3	82	5.81	5.6	5.43	4.97	3.02	22.5
profile 4	200	3.47	5.62	5.94	6.95	6.55	10.3
profile 5	209	4.03	6.49	6.27	5.85	4.02	55.6
profile 6	7	8.2	4.56	9	6.54	9	1.3

Note. N=Neuroticism. E=Extraversion. O=Openness. A=Agreeableness. C=Conscientiousness. ADHD%=percentage of children with ADHD who fell into specific profile groups.

Table 4

Latent Profile External Validation and Correlates

	Disagreeable	Introverted	Poor Control	Well-Adjusted	Extraverted	Perfectionistic
<i>Frequencies(percentages)</i>						
Control	1(20%)	13(28%)	4(5%)	158(78%)	21(10%)	2(29%)
ADHD	1(20%)	30(65%)	68(85%)	31(15%)	168(80%)	4(57%)
ADHD-C/ADHD-PI	1(20%)/0	4(9%)/20(43%)	36(45%)/13(16%)	10(5%)/14(7%)	85(40%)/39(19%)	1(14%)/0
ADHD+ODD/CD	0	4(9%)	44(55%)	3(2%)	67(32%)	1(14%)
ADHD+mood	0	6(13%)	9(11%)	0	16(8%)	2(29%)
ADHD+anxiety	0	3(7%)	8(10%)	1(1%)	17(8%)	0
ODD	3(60%)	6(13%)	49(61%)	22(11%)	80(38%)	1(14%)
CD	0	0	6(8%)	1(0%)	12(6%)	0
MDD	1(20%)	7(15%)	5(6%)	8(4%)	18(9%)	2(29%)
Dysthymia	0	0	6(8%)	2(1%)	5(2%)	0
GAD	0	5(11%)	11(14%)	10(5%)	19(9%)	0
<i>Means (standard deviations)</i>						
Inatt (P)	7.33(9.45)	12.53(6.63)	18.67(5.32)	4.51(5.27)	17.11(6)	22(0)
Hyper (P)	4.67(7.23)	2.97(2.86)	13.41(7.32)	2.86(4)	12.33(6.91)	8(0)
Inatt (T)	12(8.19)	10.81(8.55)	13.54(7.37)	3.46(5.10)	14.44(7.03)	11(0)
Hyper (T)	9(6)	3.39(4.59)	9.14(8.49)	2.25(4.79)	10.28(7.51)	8(0)
Anx/Dep	6(4.58)	4.03(2.97)	7.56(4.47)	2.58(2.75)	3.58(2.98)	3.6(3.13)
W/Dep	7.33(6.03)	3.69(3.31)	3.4(2.94)	1.73(2.27)	2.32(2.33)	3.4(4.39)
Attn Prob	2(1.73)	8.16(4.74)	11.19(3.65)	2.5(3.15)	9.77(4.3)	9.2(6.06)
Aggress	10.67(6.03)	3.38(3.42)	12.60(5.69)	3.03(3.82)	9.75(7.25)	4.8(4.38)
Parent ADHD	7(2.65)	6.4(4.92)	11.5(7.92)	6.74(5.13)	8.36(5.45)	11(10.15)
Parent DA	10.67(10.07)	11.6(17.38)	17.96(18.52)	9.63(11.06)	11.48(11.34)	8.67(12.42)
Neuroticism	24(4.24)	20.14(8.34)	25.61(8.5)	18.54(8.16)	21.43(10.58)	25(10.58)
Extraversion	25(4.24)	26.97(6.89)	28.53(6.15)	28.98(6.29)	28.9(8.99)	22.93(2)
Openness	36(1.41)	26.65(6.4)	26.8(6.16)	29.26(5.99)	29.3(8.53)	23.67(6.81)
Agreeableness	37(1.41)	33.9(4.59)	31.1(5.71)	34.62(5.9)	34.32(7.94)	38.33(2.08)
Conscientiousness	33.5(2.12)	33.09(5.22)	31.49(6.46)	35.5(6.15)	32.32(9.89)	32.06(10.45)

Note. Inatt(P)/Hyper(P)=parent-rated inattention/hyperactivity-impulsivity on ADHD RS. Inatt(T)/Hyper(T)=teacher-rated inattention/hyperactivity-impulsivity on ADHD RS. Anx/Dep=Anxious/ depressed raw score from CBCL. W/ Dep=Withdrawn/ depressed raw score from CBCL. Attn Prob=Attention problems raw score from CBCL. Aggress=Aggressive behavior raw score. ADHD=ADHD Index score from CAARS. DA=Total score from the SCL-90. Total percentages down rows.