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Functional Outcomes of Young Adults with Childhood ADHD: A Latent Profile Analysis

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Abstract

Objective.—Adults with childhood Attention-Deficit Hyperactivity Disorder (ADHD) experience impairment in core functional domains (e.g., educational attainment, occupational status, social relationships, substance abuse, and criminal behavior), but it is currently unclear which impairments co-occur and whether subgroups experience differentiable patterns, none, or all aforementioned functional domains. Latent profile analysis (LPA) was used to characterize patterns of impairment.

Method.—Data from the Pittsburgh ADHD Longitudinal Study were used. Participants were 317 25 year-olds with childhood ADHD. LPA characterized the variability across substance use (alcohol consumption, cigarette smoking, marijuana use), criminal behavior, peer impairment, educational attainment, maternal relationship, financial dependence, and sexual activity among young adults with childhood ADHD. Childhood predictors of profiles were examined, and ADHD profiles were compared to a matched comparison group without ADHD also followed longitudinally ($n = 217$).

Results.—Five profiles were found: prototypic impairment group (54%), high binge drinking group (17%), high marijuana use group (10%), high criminal activity group (3%), and high cross-domain impairment group (17%). All profiles were impaired compared to non-ADHD young adults. Childhood variables rarely significantly predicted profiles.

Conclusions.—Young adults with childhood ADHD have differentiable impairment patterns that vary based on substance use, criminal behavior, and number of clinically impaired domains. Nearly all young adult ADHD profiles were impaired in peer, educational, and financial domains, and there was not a non-impaired ADHD profile. Use of specific substances was elevated among subgroups of, but not all, young adults with ADHD histories. Finally, the high cross-domain impairment profile was impaired in all domains.

Keywords

ADHD; longitudinal; latent profile analysis; functional impairment

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by primary symptoms of inattention and hyperactivity/impulsivity (Diagnostic and Statistical Manual of Mental Disorders: *DSM-5*; American Psychiatric Association,

2013; Nigg & Barkley, 2014). Impairments in childhood include academic underperformance, deficits in peer relationships, and problems interacting with adults (Nigg & Barkley, 2014). ADHD persists into adolescence and adulthood in most cases and is associated with continued impairment and large societal, familial, and individual costs, although severity of dysfunction varies across individuals (Hechtman et al., 2016; Pelham, Foster, & Robb, 2007; Robb et al., 2011; Sibley, Pelham, Molina, Gnagy, Waschbusch, et al., 2012; Sibley, Pelham, Molina, Gnagy, Waxmonsky, et al., 2012).

Available prospective, longitudinal research has utilized variable and group-centered approaches to investigate differences between adults with and without childhood ADHD across domains of functioning (e.g., Milwaukee Longitudinal Study of Hyperactive children [Barkley, Murphy, & Fischer, 2008]; McGill prospective studies [Weiss & Hechtman, 1993]; Multimodal Treatment of ADHD Study [Hechtman et al., 2016]; New York Study [Klein et al., 2012]; Pittsburgh ADHD Longitudinal Study [Molina, Sibley, Pedersen, & Pelham, 2016]). Studies consistently indicate higher risk for negative outcomes among ADHD probands versus non-ADHD comparison groups across core impairment domains including educational attainment, financial outcomes, social functioning, criminal behavior, and substance use, and such findings have been critical to our understanding of the life course of ADHD. At the same time, prospective longitudinal studies indicate marked variability in adult outcome among those diagnosed with ADHD in childhood (detailed below).

This variability in adult outcome mirrors the well-known heterogeneity of childhood ADHD symptomatology and associated impairments (Barkley, 2015; Pelham, Fabiano, & Massetti, 2005). ADHD is comprised of three major symptoms—hyperactivity, impulsivity, and inattention, and, consistent with all mental health problems, impairment is necessary for diagnosis, and comorbidity is common. Importantly, the impairment that characterizes children with ADHD varies considerably across children. For example, it has long been known that many children with ADHD have serious problems with peer relationships (Hoza et al., 2005; Pelham & Bender, 1982). Some are aggressive towards peers while others have an interrupting/intrusive style that, although not aggressive, interferes with peers' activities. Inappropriate classroom behavior (e.g., disruptive behavior) and poor academic achievement characterize many, but not all, children with ADHD. Finally, children with ADHD experience heightened conflict with parents, teachers, and other adults, and many parents of children with ADHD demonstrate inappropriate parenting practices (e.g., authoritarian and inconsistent; Johnston & Chronis-Tuscano, 2015; Musser, Karalunas, Dieckmann, Peris, & Nigg, 2016).

When taken together, it is clear that the variability in core symptom presentation and concurrent problems in daily life functioning likely give rise to a number of different types of children with ADHD that may vary in longitudinal outcome. It is important to investigate the diversity of adult outcomes among children with ADHD (i.e., multifinality; Cicchetti & Rogosch, 1996), which may be as heterogeneous as childhood ADHD and able to be best described in terms of cross-domain functioning among individuals. When investigating the variability in long-term outcome of childhood ADHD, the focus is often on comorbidity and symptom persistence (e.g., Agnew-Blais et al., 2016; Hechtman et al., 2016; Yoshimasu et al., 2018). However, utilizing a framework that focuses instead on variability or patterns of

cross-domain impairments in daily life functioning in adulthood, aligning with the focus on impairment in childhood, may be beneficial to our understanding of the outcomes of childhood ADHD. This approach is distinct from but not unlike the approach taken by Krueger and others who apply a similarly non-DSM-based framework to adult psychopathology (Kotov et al., 2017; Krueger, Markon, Patrick, Benning, & Kramer, 2007), though we focus solely on functional impairment herein.

The literature focused on impairment among adults with childhood ADHD has exclusively applied group-centered analyses and generally taken the approach of independently examining functional outcome domains (e.g., Barkley et al., 2006, Sibley et al., 2011, Weiss & Hechtman, 1993) cumulatively indicating marked impairment among those with ADHD histories across a variety of core functional domains. Yet, prior studies have failed to characterize patterns of ADHD-related impairment across functional domains in adulthood. Specific profiles of various impairments may suggest functional relationships that could pinpoint mechanisms for research and targets for treatment. Person-centered analysis (e.g., latent profile analyses [LPA]), in contrast to group- and variable-centered approaches used previously, has the potential to improve understanding of longitudinal outcomes among adults with ADHD histories by deriving subgroups of individuals who have differentiable patterns of scores on a set of variables. Despite its utility in characterizing cross-domain functioning, LPA has not yet been employed to characterize the diverse set of negative outcomes that likely characterize young adults with ADHD. LPA can potentially facilitate exploration of the functional relationships between the domains previously identified as impaired among adults with ADHD histories—that is, educational attainment, financial/vocational outcomes, interpersonal functioning (e.g., relationships with parents, peers, and significant others), substance use (e.g., alcohol, marijuana, and cigarettes), and antisocial behavior/criminal activity (Barkley, Murphy, & Fischer, 2008; Hechtman et al., 2016; Molina et al., 2014; Weiss & Hechtman, 1993).

In order to investigate patterns of co-occurring ADHD-related functional impairment in adulthood, we first review the literature on these core domains and highlight findings that suggest which impairments may co-occur among young adults with ADHD histories. First, the majority of adults with ADHD histories evidence continued achievement deficits and limited educational attainment. Overall, prospective longitudinal studies indicate that adults with childhood ADHD are less likely to graduate from high school and less likely to enroll in and complete higher education (Barkley, Fischer, Smallish, & Fletcher, 2006; Kent et al., 2011; Klein, 2012; Kuriyan et al., 2013; Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1993; Mannuzza, Klein, Bessler, Malloy, & Hynes, 1997). About a fourth of ADHD probands enroll in 4-year institutions (compared to 77% of controls; Barkley et al., 2006; Kuriyan et al., 2013), and only 11% to 15% earn bachelor's degrees by their mid-twenties compared to about half of demographically-similar peers (Hechtman et al., 2016; Kuriyan et al., 2013; Mannuzza et al., 1997, 1993).

Analogous and related to their educational impairment, adults with childhood ADHD, on average, achieve lower occupational statuses and are more likely to be unemployed (Barkley et al., 2008; Hechtman et al., 2016; Klein et al., 2012; Kuriyan et al., 2013; Mannuzza et al., 1997, 1993) despite having comparable IQs and family socioeconomic status as controls. In

terms of financial outcomes and independence, at age 25, individuals with ADHD have lower annual income, more credit card debt, and are more likely to be living with and otherwise financially dependent on their parents and public subsidies compared to typically developing peers (Altszuler et al., 2016). In the Altszuler and colleagues study (2016), there was variability in the ADHD sample with lower education and higher delinquency predicting poorer financial outcomes. Therefore, those with higher educational attainment are likely to have higher financial success.

Childhood ADHD also predicts social impairment into young adulthood (Biederman et al., 1995; Molina et al., 2014; Weiss & Hechtman, 1993) and continued difficulty getting along with others, including peers and family members (Barkley et al., 2006). Although young adults with and without childhood ADHD report similar rates of dyadic relationships (Barkley et al., 2006), those with ADHD histories report increased risky sexual behaviors such as a higher number of sexual partners, more partner violence, and lower consistency of birth control use (Barkley et al., 2006; Flory, Molina, Pelham, Gnagy, & Smith, 2006; Wymbs et al., 2012). Based on their childhood characteristics, some adults with childhood ADHD would be expected to have a range of intrusive social styles that would cause problems with coworkers and may contribute to their vocational difficulties (e.g., frequent job changes). Further, childhood peer problems predict a host of problems in adulthood (e.g., criminal activity and substance use) both within (Lee & Hinshaw, 2004; Satterfield et al., 2007) and outside of (Dishion, 2014; Hawkins, Catalano, & Miller, 1992; Huesmann, Eron, Lefkowitz, & Walder, 1984) the ADHD literature that may then co-occur with adult social impairment.

Another domain of dysfunction among adults with childhood ADHD is substance use, including alcohol, marijuana, and tobacco. Molina and Pelham (2014) reviewed numerous papers that examine substance use outcomes in ADHD, and elevations in alcohol, marijuana, and tobacco use were evident at the group-level across samples (Barkley et al., 2008; Lambert & Hartsough, 1998; Molina & Pelham, 2003; Pedersen et al., 2016; Rhodes et al., 2016; Sibley et al., 2014). The rate of current substance use disorders is elevated, ranging from 12% to 16% throughout adulthood for those with ADHD histories compared to about 4% in control adults (Derefinko & Pelham, 2016; Hechtman et al., 2016; Klein et al., 2012; Mannuzza et al., 1993; Mannuzza, Klein, Bessler, Malloy, & Lapadula, 1998). Further, young adults with childhood-ADHD are more likely to be daily smokers and report heightened withdrawal and craving during cigarette abstinence (Fuemmeler, Kollins, & McClernon, 2007; Lambert & Hartsough, 1998; Rhodes et al., 2016). Notably, there is variability in these outcomes—that can be explored with LPA—with regard to the number of individuals who exhibit problems in substance use, severity of use, and substance being used such that it is currently unclear if some ADHD individuals are using a variety of substances and what proportion are not using any substances. Similarly, LPA may elucidate whether heightened substance use co-occurs with social problems or other functional impairments among young adults with ADHD histories.

Antisocial behavior and aggression are also more severe among young adults with childhood ADHD compared to peers (Weiss & Hechtman, 1993). Young adults with ADHD histories are more likely than peers to have committed a variety of crimes such as disorderly conduct,

assault with fists and with a weapon, setting serious fires, and stealing property (Barkley et al., 2006; Hechtman et al., 2016; Molina et al., 2009; Sibley et al., 2011), and longitudinal research shows that criminal outcomes are predicted by impaired social relationships in childhood (Loeber, Farrington, Stouthamer-Loeber, & Van Kammen, 1998). However, group- and variable-centered analytic approaches have not provided information about whether individuals in ADHD samples who are engaging in criminal behavior are also presenting with impairment in other core domains of functioning such as substance use and social problems.

Altogether, the literature using group-centered analyses to investigate adult outcomes of childhood ADHD indicates poor functioning at the group-level in academic, vocational/financial, social/interpersonal, substance use, and criminal domains, though only a portion of adults with ADHD histories experience each negative outcome. However, no study has empirically examined whether negative outcomes occur within the same individuals across some or all of these core impairment domains. It is likely that co-occurring problems in adulthood are common as most adolescents with childhood ADHD experience difficulties in multiple domains across symptoms, academic functioning, and social functioning (Lee, Lahey, Owens, & Hinshaw, 2008), though which impairments or symptoms were most likely to co-occur among adolescents was not examined. Based on a recent study that categorized adults with childhood ADHD as symptom-persistent or –desistent, it appears that educational and vocational impairments co-occur and are ubiquitous among those with ADHD histories whereas substance use problems are less common (Hechtman et al., 2016). As the ADHD sample in that study was categorized based on symptoms, not impairment, however, co-occurrence of functional impairment was not empirically evaluated as is possible with person-centered analyses. Studies investigating co-occurring problems in non-ADHD populations indicate that vocational and educational outcomes are often related (Dubow, Huesmann, Boxer, Pulkkinen, & Kokko, 2006) and that criminal behavior co-occurs with polysubstance use (Moss, Chen, & Yi, 2007; Windle & Scheidt, 2004). Indeed, one would expect externalizing problems in general (e.g., aggression and substance use) to be functionally related (Kotov et al., 2017; Krueger et al., 2007).

Investigating multifinality across the diverse set of dysfunctional outcomes of childhood ADHD is an important extension of the available literature, and a person-centered statistical approach (i.e., LPA) would appear to be a useful next step in characterizing relationships among these negative outcomes. Using person-centered analyses would allow individuals with ADHD histories to be separated into subgroups that have similar patterns of impairments across the variables examined. Such analyses provide information beyond what is available from group-centered approaches such as whether a subgroup of ADHD probands is unimpaired across domains or, alternatively, impaired across many domains and which impairments are most likely to co-occur among adults with ADHD histories. Despite these advantages, person-centered analyses have not been used in prospective, longitudinal ADHD research.

The current study aimed to utilize a person-centered approach to investigate the co-occurrence of functional impairment among young adults with ADHD histories and to characterize multifinality in impairment. First, we estimated latent profiles among young

adults with childhood ADHD utilizing data from the PALS to determine patterns of functioning that best capture variability in the core impairment domains discussed above. After deriving profiles for the ADHD probands, we compared ADHD profiles to controls. We hypothesized that individuals with ADHD would cluster into groups that present with distinct patterns of impairment that may shed light on differences in long-term outcome in this population. Given the lack of available literature about the co-occurrence of functional impairments in this population, we present exploratory hypotheses as opposed to traditional hypotheses herein. We expected that poor vocational and educational outcomes would be co-occur (Altszuler et al., 2016; Dubow, Huesmann, Boxer, Pulkkinen, & Kokko, 2006). Further, we hypothesized that a subset of adults with childhood ADHD would exhibit consistently severe problems across multiple domains (Lee, Lahey, Owens, & Hinshaw, 2008). Conversely, the fact that a portion of adults with childhood ADHD do not have problems in a given domain raises the possibility that a subgroup may be relatively unimpaired across domains in adulthood. Despite this possibility of a low-impairment group of ADHD probands, we hypothesized that all or almost all ADHD profiles would be impaired compared to control young adults based on the large body of longitudinal research reviewed above. Finally, as an exploratory addition to the LPA, we examined childhood and familial predictors (e.g., demographics, child functioning, familial risk) of profile membership, and no a priori hypotheses regarding predictors were made.

Method

Participants

Pittsburgh ADHD Longitudinal Study (PALS).—The ADHD group was recruited from a pool of clinically-referred children who had attended the Summer Treatment Program (STP) at Western Psychiatric Institute and Clinic between the years of 1987 and 1996. The first wave of longitudinal follow-up spanned 1999–2003, and 364 of the original 516 study-eligible children were enrolled in PALS (493 of the original 516 were re-contacted during PALS enrollment). ADHD probands were diagnosed in childhood based on parent and teacher ratings on standard *DSM-III-R* and *DSM-IV* symptoms scales (Disruptive Behavior Disorder rating scale [DBD]; Pelham, Evans, Gnagy, & Greenslade, 1992) and semi-structured clinical and diagnostic interviews with parents administered by a PhD-level clinician. Comparison, typically developing participants (original $n = 240$) were recruited from the same geographical area at the first wave of follow-up, and recruitment lagged three months behind ADHD group enrollment to facilitate efforts to obtain demographic similarity. All families consented, and the PALS has had consistent Institutional Ethics Board approval (IRB#: REN16110041/IRB970723).

Current subsample.—Data from the age 25 wave of data collection was used for the current study. Table 1 contains demographic information. At the time of analysis, 317 participants with ADHD had at least one data point available among the functional outcome variables analyzed from the age 25 wave of data collection. No significant differences between the ADHD probands used in the current analyses and those not included ($n = 47$) were found on 10 of the 11 baseline demographic and symptom variables examined ($p > .$

05). Significantly more male ADHD probands were missing data ($p = .046$) with one female and 46 males missing age 25 data.

Controls were *not* included in the LPA but were included as a reference. At the time of analysis, 217 control participants had at least one data point available from the age 25 variables used in the profile analyses, and those included in analyses were not significantly different than those not included ($n = 23$) on demographic variables (see Table 1, $ps > .05$).

Measures

LPA Variables.—From the *Substance Use Questionnaire* (a self-report, paper and pencil questionnaire developed for PALS [Molina & Pelham, 2003]), individual items of self-reported frequencies of alcohol consumption, binge drinking (defined as 5 or more drinks in a single drinking event), cigarette smoking, and marijuana use over the last 12 months were used. The *Self-Reported Delinquency* scale (Loeber et al., 1998) was used to indicate the number of distinct criminal acts (including violent crimes, drug related offenses, and theft) that the individual engaged in during the past year.

The peer-item on the parent-report *Impairment Rating Scale* (IRS; Fabiano et al., 2006), a 0 to 6 Likert-type scale, indicated how severe impairment and need for treatment were in the peer domain. The number of sexual partners in the past 12 months was collected via self-report on the *Health and Sex Behavior Questionnaire*, developed for the PALS (Flory et al., 2006). The *Conflict Behavior Questionnaire- Adolescent Report* (this study, $\alpha = 0.95$; Prinz, Foster, Kent, & O'Leary, 1979) was used as a measure of the young adult's relationship with their mother and is scored such that a higher number indicates more dysfunctional interactions or negative attributions.

For educational level, self-report of the last grade completed was collected and reverse-coded such that a higher score indicates worse outcome as is consistent with all profile indicators. Financial dependence was used as the financial outcome due to the high relation and redundancy between educational attainment and occupational status. Parents rated how financially dependent the young adult was compared to peers of the same age on the *General Life Functioning in Adulthood* scale (Altszuler et al., 2016) on a scale from 1 ('a good deal further ahead of peers') to 5 ('a good bit behind peers').

Baseline and Wave One Predictors (ADHD group only).—Baseline refers to variables collected in childhood, and wave one refers to variables collected when participants were first interviewed for the PALS follow-up study (average of 8 years later). Twenty-one predictor variables were examined. Child gender and race and parent marital status, highest education, and household income were evaluated as predictors. Participants' estimated full-scale IQs were assessed using the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1991) or the Wechsler Preschool and Primary Scale of Intelligence (WPPSI; Wechsler, 1989) depending on the participant's age. The Woodcock-Johnson Revised (WJ; Woodcock & Johnson, 1989) was used to assess academic achievement in reading, written language, and math (after 1994, the Wechsler Individual Achievement Test [Wechsler, 1992] screener was used instead of the WJ).

Teacher ratings on the *IOWA Conners Rating Scale* (Atkins, Pelham, & Licht, 1989; Milich, Loney, Landau, & Kramer, 1982) Inattention/Overactivity (IO, $\alpha = .75$) and Oppositional/Defiant (OD, $\alpha = .92$) subscales completed at baseline indicated symptom presence and severity. Using the *SNAP* (Pelham & Bender, 1982) teacher ratings, a variable indicating peer problems was created by summing the seven peer interaction items (e.g., acts bossy, teases, annoys peers; $\alpha = .89$). Items on the *IOWA* and *SNAP* were ordered from 0 ('not at all') to 3 ('very much'). Combined parent and teacher ratings on the DBD were used to indicate inattention ($\alpha = .97$) and hyperactive/impulsive ($\alpha = .96$) symptom severity at baseline (Pelham, Evans, Gnagy, & Greenslade, 1992). Raw scores on the anxious/depressed and withdrawn/depressed composite scales were from the *Child Behavior Checklist* (Achenbach, 1991).

At the first wave of the PALS follow-up, a combination of the *Michigan Alcohol Screening Test* (MAST; Selzer et al., 1975; Sher & Descutner, 1986) and the *Structured Clinical Interview for DSM-IV* (SCID), Nonpatient Edition was used to derive an index of paternal alcohol problems (see Molina, Gnagy, Joseph, & Pelham, 2016). The *Mann Family Tree* (Mann, Sobell, Sobell, & Pavan, 1985) was used to determine alcohol problems among males by dividing the number of male relatives endorsed to have problems by the number of male relatives. The *Alcohol/Substance Use During Pregnancy* scale was developed for the PALS, administered at wave one, and individual, self-report items assessing the use of cigarettes and alcohol by the biological mother while pregnant were used. Maternal depression was evaluated using the *Beck Depression Inventory* (BDI; Beck, Epstein, Brown, & Steer, 1988; $\alpha = .89$) at wave one with higher scores indicating more severe depressive symptoms.

Analyses

LPA was completed in Mplus Version 7.3 (Muthén & Muthén, 1998–2015) using a maximum likelihood framework robust to non-normality (MLR). LPA is not affected by slight differences in scaling in the profile indicator variables (Vermunt & Magidson, 2002). Multiple indices of model fit (Bayesian Information Criteria [BIC] where a lower value indicates better fit, log-likelihood ratio test [LRT] where a significant comparison indicates the model with a higher number of parameters has significantly better fit, and entropy with values approaching one indicating better classification of individuals into profiles [Celeux & Soromenho, 1996; Nylund, Asparouhov, & Muthén, 2007]) in conjunction with theory-based decision-making and interpretability influenced the profile model chosen.

LPA variables were collected when ADHD probands were 25 years-old (see Table 2 for variable scales). Mean differences between ADHD profiles and control participants on profile variables were evaluated via one-way ANOVA, and significant differences between controls and ADHD profiles indicate impairment. Baseline and wave one variables were included in the LPA as auxiliary variables, allowing them to influence profile membership and be evaluated as predictors of profile membership within a single model that accounts for measurement error in profile membership (Lanza, Tan, & Bray, 2013). Group differences on auxiliary variables were explored via Wald Chi-Square tests utilizing 20 pseudo-class draws of profile membership to account for the probabilistic assignment of individuals to profiles

(Clark & Muthén, 2009). Pairwise comparisons were evaluated when the overall Wald Chi-Square value was significant at $p < .01$ due to multiple comparisons.

Results

Latent Profiles

Fit indices for one-profile to six-profile solutions are presented in Table 3. The six-profile solution was difficult to interpret due to the high number of profiles, and the distinctions between additional individual profiles lacked theoretical relevance. We therefore discontinued investigating models with a higher number of profiles. The three-profile and five-profile models optimally classified individuals into profiles (entropy = .90), and the LRT and BIC continually indicated improved model fit for models with a higher number of profiles. Importantly, both the BIC and LR model fit indices take parsimony into account and include a ‘penalty’ for increasing the number of profiles (Tein, Coxe, & Cham, 2013). As such, examination of the combination of fit indices and interpretability of profiles indicated that a five-profile model provides the best solution, entropy = 0.91, BIC = 10312.93, LRT, $\chi^2(11) = 146.96$, $p < .001$. Although profile 4 in the five-profile model contains only 3.15% of the sample (10 participants), this profile was consistent in the three-, five-, and six-profile models, and the four-profile model was associated with decreased entropy.

The final five-profile model is depicted in Figure 1 and Table 4 (along with control averages for reference). We labeled each ADHD profile based on the patterns of functioning across domains and differences from controls (see Table 4): 1) prototypic impairment group, 2) high binge drinking group, 3) high marijuana use group, 4) high criminal activity group, and 5) high cross-domain impairment group.

Profile 1, the prototypic impairment group, contains 54% of the sample. It is labeled ‘prototypic impairment’ due to impairment across domains commonly identified in the literature as impaired among children and adolescence with ADHD, because these impairments were mostly present in every other profile as well—that is educational, peer, and financial impairment, and because it is the largest profile. This profile is characterized by relatively low substance use across alcohol (drinking 8–11 times per year, binge drinking less than once per year), cigarettes (less than one cigarette per day), and marijuana (less than once per year), and relatively low to negligible criminal activity (less than one criminal act). Compared to controls, these individuals were significantly impaired in peer relationships, maternal relationship, educational attainment, and financial independence, and they also engaged in significantly less substance use (see Table 4).

Profile 2, the high binge drinking group, contains 17% of the sample. Individuals in this group were consuming alcohol once a week, binge drinking 2–3 times per month, and smoking 1–5 cigarettes per day. Yet, only their frequencies of binge drinking and cigarette smoking, not frequency of any alcohol use, are significantly higher than controls (Table 4). The high binge drinking group is not engaging in marijuana use or criminal behavior. Social impairment and financial dependence appear to be lowest in this group. This group engaged

in significantly less marijuana use than controls, and altogether had the lowest number of significant differences from controls (Table 4).

Profile 3, containing 10% of the sample, is the high marijuana use group. These individuals were smoking marijuana once per day, consuming alcohol once per month, binge drinking 1–3 times per year, and smoking about half a pack of cigarettes per day. As shown in Table 4, the high marijuana use group engaged in significantly less alcohol and binge drinking and significantly more cigarette smoking and marijuana use than controls. They were also significantly impaired compared to controls in peer relationships, educational attainment, and financial dependence.

Profile 4, containing only 3% of this sample, is the high criminal activity group. These individuals are distinctly characterized by a relatively high number of criminal acts committed in the previous year (average of 8 distinct self-reported criminal acts) and markedly high peer relationship impairment. Young adults in this group were consuming alcohol 4–7 times per year, binge drinking less than once per year, smoking 1–5 cigarettes per day, and using marijuana less than once per month—which are all at or significantly below the rate of substance use in the non-ADHD group (Table 4). However, individuals in the high criminal activity group were committing more crimes, were more financially dependent, had lower educational attainment, and had more problems in peer and maternal relationships than controls.

Profile 5, containing 17% of the sample, is the high cross-domain impairment group. These individuals were consuming alcohol and binge drinking 2–3 times per week, smoking half a pack of cigarettes per day, and using marijuana 4–6 times per week. Individuals in the high cross-domain impairment group reported committing 2 distinct criminal acts in the last year, had maternal relationship problems, were financially dependent, and had an average of 4 sexual partners per year. ADHD probands in the high cross-domain impairment group were significantly impaired relative to controls on all profile variables (Table 4).

Differences on Predictor Variables

Of the 21 auxiliary variables, profiles were not significantly different on 19 variables at the p -value of .01. Biological sex was significantly different between the prototypic impairment group (82% male) and both the high cross-domain impairment and high criminal activity groups (96% and 100% male, respectively), $p < .001$. Other demographic and child baseline variables (i.e., child race, parent marital status and education, household income, IQ, and achievement scores, ADHD symptoms [inattentive and hyperactive/impulsive], oppositional behavior, anxiety, depression, and peer impairment) were not significantly different across profiles ($ps > .01$).

In terms of familial risk factors, maternal alcohol use during pregnancy ($p = .002$) was significantly different across groups. Specifically, the prototypic impairment group was significantly higher in maternal alcohol use during pregnancy than the high binge drinking and high criminal activity groups. Other familial risk variables (i.e., paternal alcohol use, alcohol problems among male relatives, smoking while pregnant, and maternal depression) were not significantly different among profiles ($ps > .01$).

Discussion

This study is the first to use person-centered analyses to characterize the variability and multifinality of longitudinal outcome among children with ADHD, and, specifically, focus was placed on core areas of impairment (educational/financial functioning, social functioning, substance use, and criminal behavior). Results indicated that 1) children with ADHD present with at least five distinct patterns and levels of impairment in young adulthood largely differentiated by substance use, criminal behavior, and number of clinically impaired domains, 2) all empirically-derived subgroups of young adults with childhood ADHD were impaired compared to controls, specifically in terms of peer relationships, educational attainment, and financial dependence, and 3) childhood predictors of young adult functioning were rarely significant. These findings are discussed in turn below.

Profiles of impairment indicate that substance use varies systematically among young adults with childhood ADHD. The three profiles that exhibited relatively high substance use behaviors were the high marijuana use, high binge drinking, and the high cross-domain impairment groups, accounting for about 43% of young adults with ADHD histories. Importantly, for any given substance, the ADHD probands bifurcated in their use. Results suggest that childhood ADHD confers risk for heightened alcohol use for some and predicts below normative use for others, consistent with previous work in this longitudinal sample. Molina and colleagues (2014) empirically delineated two distinct developmental pathways toward alcohol use among young adults with ADHD, with a delinquency pathway conferring increased risk for alcohol use (i.e., high cross-domain impairment group) and a social impairment pathway conferring decreased risk in young adulthood (i.e., prototypic impairment group). The differing pathways may explain somewhat confusing meta-analytic findings indicating that adults with ADHD are at greater risk for alcohol use disorders than their peers, but do not consume more alcohol in their lifetime, on average (Lee, Humphreys, Flory, Liu, & Glass, 2011). This is consistent with our findings that the ADHD subgroup that endorsed the least amount of alcohol use (even compared to non-ADHD young adults) also demonstrated the highest level of impairment in peer relationships (i.e., high criminal activity profile).

The profiles also indicate that, for individuals with ADHD, heightened cigarette use co-occurs with substance use (i.e., alcohol and marijuana use). This extends previous literature indicating that ADHD and drug use disorders uniquely relate to daily smoking and nicotine dependence (Lambert & Hartsough, 1998; Rohde, Kahler, Lewinsohn, & Brown, 2004) and that cigarette smoking is a risk factor for concurrent and later substance use among youth with ADHD (Biederman, Petty, Hammerness, Batchelder, & Faraone, 2012; Molina et al., 2013). Marijuana use also provided an interesting distinction among young adults with childhood ADHD, with about 26% using marijuana more and 70% using marijuana less than comparison young adults. The varying risk for later substance use is important for researchers to consider when evaluating substance use at the group-level (ADHD vs. non-ADHD) as such analyses may obscure potentially important addiction-prone subgroups with unique vulnerabilities associated with ADHD or its impairments. Altogether, multifinality in ADHD substance use outcome is apparent in generalized substance use (e.g., high cross-

domain impairment group) and substance-specific risk pathways (e.g., high binge drinking group and high marijuana use group; Molina & Pelham, 2014). Finally, it also suggests potential pathways to emergence of substance use disorder at older ages when developmentally-limited substance use tends to decline. Exacerbation of ADHD-related impairments from substance use, and vice-versa, may partially explain the higher number of alcohol-related problems that we recently reported for the ADHD group at mean age 29 (Pedersen et al., 2016).

Adults in the high criminal activity group reported engaging in an average of eight distinct criminal acts in the last year, and high criminal behavior co-occurs with impaired interpersonal relationships, relatively high financial dependence, and relatively low substance use among young adults with childhood ADHD. Later aggression and criminal activity are related to disturbed peer relationships in childhood (e.g., few friends, aggression; Huesmann et al., 1984), and it follows that social impairment and criminal behavior would co-occur in adulthood. Although all ADHD profiles had peer problems, the high criminal activity group had markedly higher peer problems than did all other ADHD profiles (one standard deviation higher) and controls (two standard deviations higher). Further, individuals who engage in criminal behavior during adulthood tend to have life-course-persistent antisocial behavior, which is costly to society (Moffitt, 2006).

Person-centered analyses identified a high cross-domain impairment group that is impaired in more domains than any other ADHD profile (i.e., educational/financial, social/interpersonal, substance use, and criminal activity) compared to controls. Highlighting a subgroup of children with ADHD who are contributing highly to the lifetime societal cost of ADHD as the impairments this group exhibits (e.g., binge drinking once per week, using marijuana daily, and engaging in risky sexual behavior and criminal activity) are the behaviors that lead to high costs from lost productivity, healthcare needs, and the criminal justice system (Pelham, Foster, & Robb, 2007). Interestingly, research into the typology of alcoholism converges on a similar subset described as polydrug users or antisocial subtype that engage in high binge drinking, non-alcohol substance use, criminal behavior, and risky sexual behavior (Moss et al., 2007; Windle et al., 2004), who may overlap to an extent with this sub-group presenting with ADHD in childhood. Further, these results align with research on the dimensionality of adult externalizing problems which has indicated that substance use and conduct problems are related via a higher-order disinhibited externalizing factor (Kotov et al., 2017).

Of particular importance for understanding long-term outcome is that children with ADHD, regardless of profile membership, have impaired peer functioning, educational attainment, and financial independence in young adulthood relative to the non-ADHD group. This is exemplified by the prototypic impairment profile (54% of the sample), as their major impairments are the same that they had in childhood and adolescence (i.e., problems in relationships with peers, relationships with parents, and academic achievement), in addition to domains that weren't relevant when they were younger (i.e., vocational functioning, financial independence), and nearly all ADHD profiles are impaired in these domains. This homotypic continuity of impairments from childhood to young adulthood extends numerous variable-centered, as opposed to person-centered, findings in the literature to underscore that

even when an attempt is made to identify subgroups of children with variable outcomes, social, educational, and financial impairments appear to be universal. In other words, a low impairment group did not emerge among the young adults with ADHD histories. Very few children with ADHD are financially independent or earning bachelor's degrees in young adulthood, despite relatively high parental education in the PALS sample. These pervasively impaired areas, coupled with the long-term societal and individual cost of ADHD (Altszuler et al., 2016; Biederman & Faraone, 2006; Pelham et al., 2007), indicate that an ADHD diagnosis in childhood is clearly sufficient to indicate need for preventive interventions to address future financial, educational, and social impairment.

Childhood and familial risk factors were rarely significant predictors of adult functioning. Of the 21 auxiliary variables examined, two were significant predictors. Child biological sex was significant due to the high rates of males in the high criminal activity (100%) and high cross-domain impairment (96%) profiles compared to the prototypic impairment profile (82%). Aligning with research indicating girls with ADHD are not at heightened risk for substance use problems or delinquency (Hinshaw et al., 2012), results herein show that boys with ADHD are more likely than girls to engage in criminal activity and polysubstance use in adulthood. Further, increased maternal alcohol consumption while pregnant predicted membership in the prototypic impairment profile compared to the high binge drinking and high criminal activity profiles. Given the high criminal activity group includes only 10 participants, we advise caution when interpreting this effect. Though it is surprising that higher prenatal alcohol consumption predicts not belonging to the high binge drinking profile, it is important to note that the high binge drinking profile's alcohol use pattern is most similar to the non-ADHD controls' alcohol use pattern. Additionally, it is often the case in the ADHD longitudinal literature that childhood predictors are not significant when not including controls in analyses, likely due to the restricted variability at baseline within a clinical sample (Roy et al., 2016).

Limitations and Future Directions

Prediction from childhood may have been limited by the time gap between predictors and outcome and the developmental non-specificity of baseline predictors. Children in the PALS sample were recruited via participation in a treatment program, and as such they varied in age at baseline and there may have been artificially limited variability due to severe baseline functioning. Future research should examine specific predictors based on each profile, and it is likely that developmentally- or domain-sensitive variables, such as early parenting behavior, adolescent initiation of substance use, or association with a deviant peer group, would provide better prediction (e.g., Molina et al., 2014). For example, adolescent onset of substance-specific use may predict membership in that substance-specific profile in adulthood. Given the explicit focus of this paper on functional impairment, we did not evaluate variations in internalizing comorbidities in adulthood. We did, however, examine childhood internalizing problems as a predictor of adult impairment, and the result was not significant. Future research with larger samples may be needed to investigate patterns of co-occurring diagnoses and impairment.

Further, the stability of the profiles cannot be established within the current analyses. Future research should compare profile membership across ages and samples, particularly in order to replicate the high criminal activity group, which includes a small subset of this sample (3%, $n = 10$). This profile was stable at the three-, five-, and six-profile models and associated with improved entropy, but replication is needed. Instability in profiles across periods of adulthood may be expected given that substance use largely differentiated the profiles herein and declines after young adulthood among non-ADHD individuals (Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2016). Lastly, most profile indicators were single-items. We selected the items carefully based on previous research, and the robustness of LPA is not impacted by this. However, results may have been different if composite scores were used.

Clinical Implications

Using person-centered analyses, patterns of functional impairment outcomes among individuals with ADHD histories were derived that significantly add to the understanding of the outcomes associated with childhood ADHD. Critically, a subgroup of ADHD probands that evidenced positive outcomes was not identified. It is important for clinicians who work with families and teachers of children and adolescents with ADHD to be aware of the potential long-term outcomes for children with ADHD, as this is often a primary parental concern. Clinicians, parents, and teachers may benefit from understanding, in clear terms, that childhood ADHD is a chronic disorder that, at this time, is likely to lead to prototypic, lifetime impairments in educational, financial, and social functioning. Clearly, more research is needed regarding promoting financial, academic, and social success among individuals with ADHD at critical periods, such as entering the workforce or preparing for college. Further, substance use was elevated in specific subgroups of young adults with ADHD histories, indicating that not all adolescents with ADHD require substance use prevention or intervention programs, and collateral information associated with later substance use, such as association with a deviant peer group, should be taken into account when choosing preventive interventions.

Conclusions

By empirically deriving profiles of impairment among young adults with childhood ADHD, we are able to characterize the relationships among critical, functional outcomes in a heterogeneous clinical population. Results indicate that young adults with ADHD histories present with distinct patterns of functional impairment that vary by substance use, criminal activity, and number of clinically impaired domains. All ADHD profiles were impaired compared to controls, most commonly on measures of educational attainment, peer relationships, and financial independence as evidenced by the prototypic impairment group. Therefore, childhood ADHD diagnosis alone is sufficient to indicate long-term difficulties with academic, financial, and social competencies and need for treatment in these key domains. Three profiles, comprising 43% of the sample, were characterized by higher substance use than controls, indicating that elevated use of at least one substance is present among subgroups of, but not all, young adults with childhood ADHD. Further, a particularly concerning subgroup of young adults with childhood ADHD was empirically identified, the

high cross-domain impairment profile (17% of the sample), that exhibits significantly elevated problems in all domains assessed (i.e., educational attainment, financial independence, social functioning, polysubstance use, and criminal behavior). This group therefore may have the greatest individual and societal costs, and, if replicated in a similar sample, this group is arguably the one in which intervention efforts should be targeted in young adulthood.

References

- Achenbach TM (1991). Manual for Child Behavior Checklist/ 4–18 and 1991 Profile. Burlington, VT: University of Vermont, Dept. of Psychiatry.
- Agnew-Blais JC, Polanczyk G, Danese A, Wertz J, Moffitt TE, & Arseneault L (2016). Persistence, remission and emergence of ADHD in young adulthood: results from a longitudinal, prospective population-based cohort. *JAMA Psychiatry*, 73, 713. [PubMed: 27192174]
- Altszuler AR, Page TF, Gnagy EM, Cox S, Arrieta A, Molina BSG, & Pelham WE (2016). Financial dependence of young adults with childhood ADHD. *Journal of Abnormal Child Psychology*, 44, 1217–1229. 10.1007/s10802-015-0093-9 [PubMed: 26542688]
- American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Arlington, VA: American Psychiatric Publishing.
- Atkins MS, Pelham WE, & Licht MH (1989). The differential validity of teacher ratings of inattention/overactivity and aggression. *Journal of Abnormal Child Psychology*, 17, 423–435. [PubMed: 2794255]
- Atkins MS, Pelham WE, & Licht MH (1989). The differential validity of teacher ratings of inattention/overactivity and aggression. *Journal of Abnormal Child Psychology*, 17, 423–435. [PubMed: 2794255]
- Barkley RA (Ed.). (2015). Attention-Deficit Hyperactivity Disorder: A Handbook for Diagnosis and Treatment (4th ed.). New York, NY: Guilford Press.
- Barkley RA, Fischer M, Smallish L, & Fletcher K (2006). Young adult outcome of hyperactive children: adaptive functioning in major life activities. *Journal of the American Academy of Child and Adolescent Psychiatry*, 45, 192–202. 10.1097/01.chi.0000189134.97436.e2 [PubMed: 16429090]
- Barkley RA, Murphy KR, & Fischer M (2008). ADHD in Adults: What the Science Says. New York, NY: Guilford Press.
- Beck AT, Epstein N, Brown G, & Steer RA (1988). An inventory for measuring clinical anxiety: psychometric properties. *Journal of Consulting and Clinical Psychology*, 56, 893. [PubMed: 3204199]
- Biederman J & Faraone SV (2006). The effects of Attention-Deficit/Hyperactivity Disorder on employment and household income. *Medscape General Medicine*, 8, 12.
- Biederman J, Petty CR, Hammerness P, Batchelder H, & Faraone SV (2012). Cigarette smoking as a risk factor for other substance misuse: 10-year study of individuals with and without attention-deficit hyperactivity disorder. *The British Journal of Psychiatry*, 201, 207–214. 10.1192/bjp.bp.111.100339 [PubMed: 22844023]
- Biederman J, Wilens T, Mick E, Milberger S, Spencer TJ, & Faraone SV (1995). Psychoactive substance use disorders in adults with attention deficit hyperactivity disorder (ADHD): Effects of ADHD and psychiatric comorbidity. *The American Journal of Psychiatry*, 152, 1652–1658. 10.1176/ajp.152.11.1652 [PubMed: 7485630]
- Celeux G, & Soromenho G (1996). An entropy criterion for assessing the number of clusters in a mixture model. *Journal of classification*, 13, 195–212.
- Clark SL, & Muthén B (2009). Relating latent class analysis results to variables not included in the analysis. <http://statmodel2.com/download/relatinglca.pdf>
- Cicchetti D, & Rogosch FA (1996). Equifinality and multifinality in developmental psychopathology. *Development and Psychopathology*, 8, 597–600.

- Dishion TJ (2014). A developmental model of aggression and violence: Microsocial and macrosocial dynamics within an ecological framework. In *Handbook of developmental psychopathology* (pp. 449–465).
- Derefinko KJ & Pelham WE (2016). ADHD and substance use In Sher KJ (Ed.) *The Oxford Handbook of Substance Use and Substance Use Disorders* (Vol. 2). Oxford University Press.
- Dubow EF, Huesmann LR, Boxer P, Pulkkinen L, & Kokko K (2006). Middle childhood and adolescent contextual and personal predictors of adult educational and occupational outcomes: a mediational model in two countries. *Developmental Psychology*, 42, 937–949. 10.1037/0012-1649.42.5.937 [PubMed: 16953698]
- Fabiano GA, Pelham WE, Waschbusch DA, Gnagy EM, Lahey BB, Chronis AM, ... Burrows-Maclean L. (2006). A practical measure of impairment: psychometric properties of the impairment rating scale in samples of children with attention deficit hyperactivity disorder and two school-based samples. *Journal of Clinical Child and Adolescent Psychology*, 35, 369–85. 10.1207/s15374424jccp3503_3 [PubMed: 16836475]
- Flory K, Molina BSG, Pelham WE, Gnagy E, & Smith B (2006). Childhood ADHD predicts risky sexual behavior in young adulthood. *Journal of Clinical Child and Adolescent Psychology*, 35, 571–7. 10.1207/s15374424jccp3504_8 [PubMed: 17007602]
- Fuemmeler BF, Kollins SH, & McClernon FJ (2007). Attention Deficit Hyperactivity Disorder symptoms predict nicotine dependence and progression to regular smoking from adolescence to young adulthood, 32, 1203–1213.
- Hawkins DJ, Catalano RF, & Miller JY (1992). Risk and protective factors for alcohol and other drug problems in adolescence and early adulthood: Implications for substance use prevention. *Psychological Bulletin*, 112, 64–105. [PubMed: 1529040]
- Hechtman L, Swanson JM, Sibley MH, Stehli MA, Owens EB, Mitchell JT, ... MTA Cooperative Group. (2016). Functional adult outcomes 16 years after childhood diagnosis of Attention-Deficit/Hyperactivity Disorder: MTA Results. *Journal of the American Academy of Child & Adolescent Psychiatry*, 55, 945–952. 10.1016/j.jaac.2016.07.774 [PubMed: 27806862]
- Hinshaw SP, Owens EB, Zalecki C, Huggins SP, Montenegro-Nevado AJ, Schrodek E, & Swanson EN (2012). Prospective follow-up of girls with attention-deficit/hyperactivity disorder into early adulthood: Continuing impairment includes elevated risk for suicide attempts and self-injury. *Journal of Consulting and Clinical Psychology*, 80, 1041. [PubMed: 22889337]
- Hoza B, Mrug S, Gerdes AC, Hinshaw SP, Bukowski WM, Gold JA, ... Arnold LE. (2005). What aspects of peer relationships are impaired in children with attention-deficit/hyperactivity disorder? *Journal of Consulting and Clinical Psychology*, 73, 411–23. 10.1037/0022-006X.73.3.411 [PubMed: 15982139]
- Huesmann LR, Eron LD, Lefkowitz MM, & Walder LO (1984). Stability of aggression over time and generations. *Developmental Psychology*, 20, 1120–1134.
- Johnston C, & Chronis-Tuscano A (2015). Families and ADHD. In Barkley RA (Ed.), *Attention-Deficit Hyperactivity Disorder: A Handbook for Diagnosis and Treatment* 191–209. New York, NY: Guilford Press.
- Johnston LD, O'Malley PM, Bachman JG, Schulenberg JE & Miech RA (2016). Monitoring the Future national survey results on drug use, 1975– 2015: Volume 2, College students and adults ages 19–55. Ann Arbor: Institute for Social Research, The University of Michigan Available at <http://monitoringthefuture.org/pubs.html>
- Kent KM, Pelham WE, Molina BS, Sibley MH, Waschbusch DA, Yu J, ... & Karch KM. (2011). The academic experience of male high school students with ADHD. *Journal of Abnormal Child Psychology*, 39, 451–462. [PubMed: 21103923]
- Klein RG, Mannuzza S, Ramos Olazagasti MA, Roizen ER, Hutchinson JA, Lashua EC, & Castellanos FX (2012). Clinical and functional outcome of childhood Attention-Deficit/Hyperactivity Disorder 33 Years Later. *Archives of General Psychiatry*, 69, 1295–1303. 10.1001/archgenpsychiatry.2012.271 [PubMed: 23070149]
- Kotov R, Krueger RF, Watson D, Achenbach TM, Althoff RR, Bagby RM, ... Zimmerman M. (2017). The Hierarchical Taxonomy of Psychopathology (HiTOP): A dimensional alternative to traditional nosologies. *Journal of Abnormal Psychology*, 126, 454–477. doi:10.1037/abn0000258 [PubMed: 28333488]

- Krueger RF, Markon KE, Patrick CJ, Benning SD, & Kramer MD (2007). Linking antisocial behavior, substance use, and personality: An integrative quantitative model of the adult externalizing spectrum. *Journal of Abnormal Psychology*, 116, 645. [PubMed: 18020714]
- Kuriyan AB, Pelham WE, Molina BSG, Waschbusch DA, Gnagy EM, Sibley MH, ... Kent KM. (2013). Young adult educational and vocational outcomes of children diagnosed with ADHD. *Journal of Abnormal Child Psychology*, 41, 27–41. 10.1007/s10802-012-9658-z [PubMed: 22752720]
- Lambert NM, & Hartsough CS (1998). Prospective study of tobacco smoking and substance dependencies among samples of ADHD and non-ADHD participants. *Journal of Learning Disabilities*, 31, 533–544. [PubMed: 9813951]
- Lanza ST, Tan X, & Bray BC (2013). Latent class analysis with distal outcomes: A flexible model-based approach. *Structural Equation Modeling: A Multidisciplinary Journal*, 20, 1–26. [PubMed: 25419096]
- Lee SS, & Hinshaw SP (2004). Severity of adolescent delinquency among boys with and without Attention Deficit Hyperactivity Disorder: Predictions from early antisocial behavior and peer status. *Journal of Clinical Child & Adolescent Psychology*, 33, 705–716. 10.1207/s15374424jccp3304 [PubMed: 15498738]
- Lee SS, Humphreys KL, Flory K, Liu R, & Glass K (2011). Prospective association of childhood attention-deficit/hyperactivity disorder and substance use and abuse/dependence: a meta-analytic review. *Clinical Psychology Review*, 31, 328–341. 10.1016/j.cpr.2011.01.006 [PubMed: 21382538]
- Lee SS, Lahey BB, Owens EB, & Hinshaw SP (2008). Few preschool boys and girls with ADHD are well-adjusted during adolescence. *Journal Of Abnormal Child Psychology*, 36, 373–383. [PubMed: 17914666]
- Loeber R, Farrington DP, Stouthamer-Loeber M, & Van Kammen WB (1998). *Antisocial behavior and mental health problems: Explanatory factors in childhood and adolescence*. Psychology Press.
- Mann RE, Sobell LC, Sobell MB, & Pavan D (1985). Reliability of a family tree questionnaire for assessing family history of alcohol problems. *Drug and Alcohol Dependence*, 15, 61–67. [PubMed: 4017879]
- Mannuzza S, Klein RG, Bessler A, Malloy P, & Hynes ME (1997). Educational and occupational outcome of hyperactive boys grown up. *Journal of the American Academy of Child and Adolescent Psychiatry*, 36, 1222–1227. 10.1097/00004583-199709000-00014 [PubMed: 9291723]
- Mannuzza S, Klein RG, Bessler A, Malloy P, & Lapadula M (1993). Adult outcome of hyperactive boys: educational achievement, occupational rank, and psychiatric status. *Archives of General Psychiatry*, 50, 565–576. 10.1001/archpsyc.1993.01820190067007 [PubMed: 8317950]
- Mannuzza S, Klein RG, Bessler A, Malloy P, & Lapadula M (1998). Adult psychiatric status of hyperactive boys grown up. *American Journal of Psychiatry*, 155, 493–498. 10.1001/archpsyc.1991.01810250079012 [PubMed: 9545994]
- Milich R, Loney J, Landau S, & Kramer J (1982). Hyperactivity, inattention, and aggression in clinical practice. *Advances in developmental and behavioral pediatrics*, 3, 1213–1247.
- Moffitt TE (2006). Life-Course-Persistent versus Adolescence-Limited Antisocial Behavior In Cicchetti D & Cohen DJ (Eds.), *Developmental Psychopathology* (2nd ed., pp. 570–598). Hoboken, New Jersey: John Wiley & Sons.
- Molina BSG, Gnagy EM, Joseph HM, & Pelham WE (2016). Antisocial alcoholism in parents of adolescents and young adults with childhood ADHD. *Journal of Attention Disorders*. 10.1177/1087054716680074
- Molina BSG, Hinshaw SP, Arnold LE, Swanson JM, Pelham WE, Hechtman L, ... Marcus S. (2013). Adolescent substance use in the multimodal treatment study of attention-deficit/hyperactivity disorder as a function of childhood ADHD, random assignment to childhood treatments, and subsequent medication. *Journal of the American Academy of Child and Adolescent Psychiatry*, 52, 250–263. 10.1016/j.jaac.2012.12.014 [PubMed: 23452682]
- Molina BSG, Hinshaw SP, Swanson JM, Arnold LE, Vitiello B, Jensen PS, ... Houck PR. (2009). The MTA at 8 years: prospective follow-up of children treated for combined-type ADHD in a multisite

- study. *Journal of the American Academy of Child and Adolescent Psychiatry*, 48, 484–500. 10.1097/CHI.0b013e31819c23d0 [PubMed: 19318991]
- Molina BSG, & Pelham WE (2003). Childhood predictors of adolescent substance use in a longitudinal study of children with ADHD. *Journal of Abnormal Psychology*, 112, 497–507. 10.1037/0021-843X.112.3.497 [PubMed: 12943028]
- Molina BSG, & Pelham WE (2014). Attention-deficit/hyperactivity disorder and risk of substance use disorder: Developmental considerations, potential pathways, and opportunities for research. *Annual review of clinical Psychology*, 10, 607–639.
- Molina BSG, Sibley MH, Pedersen SL, & Pelham WE (2016). The Pittsburgh ADHD Longitudinal Study In Hechtman L (Eds.), *Attention-Deficit Hyperactivity Disorder: Adult Outcomes and its Predictors*. Oxford University Press: New York, NY
- Molina BSG, Walther CAP, Cheong J, Pedersen SL, Gnagy EM, & Pelham WE (2014). Heavy alcohol use in early adulthood as a function of childhood ADHD: developmentally specific mediation by social impairment and delinquency. *Experimental and Clinical Psychopharmacology*, 22, 110–21. 10.1037/a0035656 [PubMed: 24611838]
- Moss HB, Chen CM, & Yi H (2007). Subtypes of alcohol dependence in a nationally representative sample. *Drug and Alcohol Dependence*, 91, 149–158. [PubMed: 17597309]
- Musser ED, Karalunas SL, Dieckmann N, Peris TS, & Nigg JT (2016). Attention-Deficit / Hyperactivity Disorder developmental trajectories related to parental expressed emotion. *Journal of Abnormal Psychology*, 125, 182–195. [PubMed: 26854504]
- Muthén LK and Muthén BO (1998–2017). *Mplus User's Guide*. Seventh Edition. Los Angeles, CA: Muthén & Muthén
- Nigg JT, & Barkley RA (2014). Attention-Deficit/Hyperactivity Disorder In Mash EJ & Barkley R (Eds.), *Child Psychopathology* (3rd ed.). New York, NY: Guilford Press.
- Nylund KL, Asparouhov T, & Muthén BO (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural equation modeling*, 14, 535–569.
- Pedersen SL, Walther CAP, Harty SC, Gnagy EM, Pelham WE, & Molina BSG (2016). The indirect effects of childhood attention deficit hyperactivity disorder on alcohol problems in adulthood through unique facets of impulsivity. *Addiction*, 111, 1582–1589. 10.1111/add.13398 [PubMed: 26999438]
- Pelham WE, & Bender ME (1982). Peer relationships in hyperactive children: Description and treatment. *Advances in Learning & Behavioral Disabilities*.
- Pelham WE, Evans SW, Gnagy EM, & Greenslade KE (1992). Teacher ratings of DSM-III-R symptoms for the disruptive behavior disorders: Prevalence, factor analyses, and conditional probabilities in a special education sample. *School Psychology Review*, 21, 285–299.
- Pelham WE, Fabiano GA, & Massetti GM (2005). Evidence-based assessment of Attention-Deficit Hyperactivity Disorder in children and adolescents. *Journal of Clinical Child and Adolescent Psychology*, 34, 449–476. [PubMed: 16026214]
- Pelham WE, Foster EM, & Robb JA (2007). The economic impact of attention-deficit/hyperactivity disorder in children and adolescents. *Journal of Pediatric Psychology*, 32, 711–27. 10.1093/jpepsy/jsm022 [PubMed: 17556402]
- Prinz RJ, Foster S, Kent RN, & O'Leary KD (1979). Multivariate assessment of conflict in distressed and nondistressed mother-adolescent dyads. *Journal of Applied Behavior Analysis*, 12, 691–700. [PubMed: 541311]
- Rhodes JD, Pelham WE, Gnagy EM, Shiffman S, Derefinko KJ, & Molina BSG (2016). Cigarette smoking and ADHD: An examination of prognostically-relevant smoking behaviors among adolescents and young adults. *Psychology of Addictive Behaviors*, 30, 588–600. [PubMed: 27824233]
- Robb JA, Sibley MH, Pelham WE, Michael Foster E, Molina BSG, Gnagy EM, & Kuriyan AB (2011). The estimated annual cost of ADHD to the US education system. *School Mental Health*, 3(3), 169–177. 10.1007/s12310-011-9057-6 [PubMed: 25110528]

- Rohde P, Kahler CW, Lewinsohn PM, Brown RA (2004). Psychiatric disorders, familial factors, and cigarette smoking: II. Associations with progression to daily smoking. *Nicotine and Tobacco Research*, 6, 119–132. doi: 10.1080/14622200310001656948. [PubMed: 14982696]
- Roy A, Hechtman L, Arnold LE, Sibley MH, Molina BS, Swanson JM, . . . MTA Cooperative Group. (2016). Childhood factors affecting persistence and desistence of Attention-Deficit/Hyperactivity Disorder symptoms in adulthood: results from the MTA. *Journal of the American Academy of Child and Adolescent Psychiatry*, 55, 937–944 e934. doi:10.1016/j.jaac.2016.05.027 [PubMed: 27806861]
- Satterfield JH, Faller KJ, Crinella FM, Schell AM, Swanson JM, & Homer LD (2007). A 30-year prospective follow-up study of hyperactive boys with conduct problems: adult criminality. *Journal of the American Academy of Child and Adolescent Psychiatry*, 46, 601–610. 10.1097/chi.0b013e318033ff59 [PubMed: 17450051]
- Selzer ML, Vinokur A, & Van Rooijen L (1975). A self-administered Short Michigan Alcoholism Screening Test (SMAST). *Journal of Studies on Alcohol*, 36, 117–126. [PubMed: 238068]
- Sher KJ, & Descutner C (1986). Reports of paternal alcoholism: Reliability across siblings. *Addictive Behaviors*, 11, 25–30. [PubMed: 3716913]
- Sibley MH, Pelham WE, Molina BSG, Kipp H, Gnagy EM, Meinzer M, . . . Lahey BB. (2014). The role of early childhood ADHD and subsequent CD in the initiation and escalation of adolescent cigarette, alcohol, and marijuana use. *Journal of Abnormal Psychology*, 123, 362–374. 10.1037/a0036585 [PubMed: 24886010]
- Sibley MH, Pelham WE, Molina BSG, Gnagy EM, Waschbusch DA, Garefino AC, . . . Karch KM. (2012). Diagnosing ADHD in adolescence. *Journal of Consulting and Clinical Psychology*, 80, 139–50. 10.1037/a0026577 [PubMed: 22148878]
- Sibley MH, Pelham WE, Molina BSG, Gnagy EM, Waschbusch DA, Biswas A, . . . Karch KM. (2011). The delinquency outcomes of boys with ADHD with and without comorbidity. *Journal of Abnormal Child Psychology*, 39, 21–32. 10.1007/s10802-010-9443-9 [PubMed: 20697799]
- Sibley MH, Pelham WE, Molina BSG, Gnagy EM, Waxmonsky JG, Waschbusch DA, . . . Kuriyan AB. (2012). When diagnosing ADHD in young adults emphasize informant reports, DSM items, and impairment. *Journal of Consulting and Clinical Psychology*, 80, 1052–61. 10.1037/a0029098 [PubMed: 22774792]
- Tein JY, Coxe S, & Cham H (2013). Statistical power to detect the correct number of classes in latent profile analysis. *Struct Equ Modeling*, 20, 640–657. doi:10.1080/10705511.2013.824781 [PubMed: 24489457]
- Vermunt JK, & Magidson J (2002). Latent class cluster analysis. *Applied Latent Class Analysis*, 11, 89–106.
- Wechsler D (1989). Wechsler Preschool and Primary Scale of Intelligence – Revised. San Antonio, TX: The Psychological Corporation.
- Wechsler D (1991). The Wechsler Intelligence Scale for Children (2nd Ed.). San Antonio, Texas: The Psychological Corporation.
- Wechsler D (1992). Wechsler Individual Achievement Test. San Antonio, TX: Psychological Corp.
- Weiss G, & Hechtman L (1993). *Hyperactive Children Grown Up: ADHD in Children, Adolescents, and Adults* (2nd ed.). New York, NY: Guilford Press.
- Windle M, & Scheidt DM (2004). Alcoholic subtypes: are two sufficient? *Addiction*, 99, 1508–1519. 10.1111/j.1360-0443.2004.00878.x [PubMed: 15585042]
- Woodcock R, & Johnson ME (1989). *Woodcock-Johnson Tests of Achievement- Revised*. Itasca, IL: Riverside Publishing.
- Wymbs B, Molina B, Pelham WE, Cheong J, Gnagy E, Belendiuk K, . . . Waschbusch DA. (2012). Risk of intimate partner violence among young adult males with childhood ADHD. *Journal of Attention Disorders*, 16, 373–383. 10.1177/1087054710389987 [PubMed: 22044962]
- Yoshimasu K, Barbaresi WJ, Colligan RC, Voigt RG, Killian JM, Weaver AL, & Katusic SK (2018). Adults with persistent ADHD: Gender and psychiatric comorbidities—A population-based longitudinal study. *Journal of Attention Disorders*, 22, 535–546. [PubMed: 27864428]

Figure 1.

ADHD Latent Profiles and Control Participant Mean Scores at Age 25. Estimated mean scores are presented for each of the five ADHD profiles. For reference, comparison young adult means are also presented. Higher values indicate greater impairment. Count outcomes include distinct criminal acts, maternal relationship problems (measured by the Conflict Behavior Questionnaire and scored as the number of negative interactions and attributions in the parent-child dyad), and number of sex partners. Refer to Table 2 for the scaling of remaining variables and the Results section for descriptions of each profile.

Table 1.

Demographic characteristics of study participants

	ADHD (<i>n</i> = 317)	Controls (<i>n</i> = 217)
	%	%
Gender (% male) ^{**}	88.3	87.6
Race		
White/Caucasian	84.9	84.8
African American	12.0	9.7
Other	3.2	5.5
Highest Parent Education [*]		
Partial High School	0.3	0
High School Grad or GED	9.4	7.4
Technical/Specialized Training	7.5	9.8
Partial College	17.6	12.6
Associate's/2-year Degree	15.0	8.4
College or University Grad	25.4	26.5
Graduate Training	24.8	35.3
Age 25 Education Level [*]		
No High School	7.0	0.5
High School Grad or GED	18.0	1.8
Vocational/Technical Training	24.9	10.1
Partial College	32.8	25.3
Associate's/2-year Degree	1.8	1.4
Bachelor's Degree	13.2	44.2
Graduate Training	2.5	16.6
Age 25 Employment Status [*]		
Unemployed	28.8	17.5
Part-time Employed	22.7	10.4
Full-time Employed	45.6	70.3
Military	2.9	1.9
Estimated Full-Scale IQ ^a (M, SD) [*]	100.11 (15.57)	111.34 (14.42)

^aAt the first wave of follow-up, the block design and vocabulary subtests from the WISC-III (Wechsler, 1991) or the WIAT-R (Wechsler, 1981), depending on participant age, were administered to estimate full-scale IQ.

^{*} ADHD and comparison samples significantly different, $p < .05$.

^{**} Participants significantly differed from nonparticipants $p < .05$.

Table 2.

Scale for variables in latent profiles (Figure 1)

Scale	Substance Use	Cigarette Smoking	Peer Impairment	Educational Level	Financial Dependence
11	Several times a day				
10	Twice a day				
9	Once a day				
8	4–6 times a week				
7	2–3 times a week	>= 2 packs a day			
6	Once a week	1 1/2 packs a day	Extreme problem	Partial High School	
5	2–3 times a month	1 pack a day		Completed HS	A good bit behind
4	Once a month	1/2 pack a day		Partial College	Somewhat behind
3	8–11 times	1–5 cigarettes per day		Completed Vocational or Technical School	About where he/she should be
2	4–7 times	< 1 cig per day		Completed 4-year Degree	Somewhat further ahead
1	1–3 times	Did not smoke		Partial Graduate School	A good bit further ahead
0	Not at all		No problem	Completed Graduate School	

Note. Substance use refers to alcohol consumption, binge drinking, and marijuana use. Variables used but not in the table include count outcomes: distinct criminal acts, maternal relationship problems (as measured by the Conflict Behavior Questionnaire and scored as the number of negative interactions and attributions the parent-child dyad have), and number of sex partners in the last year.

Table 3.

Model fit statistics

Profiles	Log-Likelihood	LRT	BIC	Entropy
1	-5390.828		10896.833	
2	-5195.505	$p < .001$	10569.535	0.870
3	-5121.830	$p < .001$	10485.535	0.932
4	-5045.658	$p < .001$	10396.539	0.882
5	-4972.18	$p < .001$	10312.930	0.905
6	-4932.647	$p < .001$	10297.213	0.856

Note. The Log-Likelihood Ratio Test (LRT) uses the difference of -2 times the Log-Likelihood between two models to evaluate whether the inclusion of additional parameters (i.e., profiles) leads to significantly improved model fit (i.e., LRT $p < .05$). A significant LRT therefore indicates that the model with a greater number of profiles fits the data significantly better than the previous model. BIC = Bayesian Information Criteria. Entropy approaching 1 indicates that individuals are well-categorized into profiles. The final model is bolded for emphasis.

Table 4.
Means and SDs for age 25 profile variables and mean differences compared to controls

	Mean (SD)						
	Non-ADHD		Profile 1, Prototypic Impairment	Profile 2, High Binge Drinking	Profile 3, High Marijuana Use	Profile 4, High Criminal Activity	Profile 5, High Cross-Domain Impairment
	n=217	n=161		n=56	n=37	n=10	n=53
Alcohol use	5.37 (2.23)	3.07 (2.33) ***		5.87 (1.16)	3.93 (2.10) **	2.56 (2.24) **	7.09 (1.28) **
Binge Drinking	3.19 (2.59)	.60 (.76) ***		4.89 (1.17) ***	1.20 (1.00) ***	.38 (.52) ***	6.40 (1.23) ***
Cigarette Smoking	2.03 (1.34)	1.91 (1.39)		2.98 (1.72) ***	3.63 (1.67) ***	2.89 (1.90)	3.55 (1.54) ***
Marijuana Use	2.35 (3.30)	.38 (.87) ***		.81 (1.383) **	8.81 (1.80) ***	2.50 (3.51)	8.33 (2.09) ***
Distinct Criminal Acts	.87 (1.35)	.63 (.91)		1.14 (1.17)	.97 (1.35)	8.00 (1.94) ***	1.92 (1.73) ***
Peer Impairment	.29 (.95)	2.14 (2.02) ***		1.31 (1.80) **	1.60 (1.78) **	4.00 (1.93) ***	2.05 (1.99) ***
Educational Attainment	2.48 (1.23)	3.72 (1.27) ***		3.96 (1.21) ***	4.00 (1.00) ***	4.10 (.74) ***	3.77 (.91) ***
Maternal Relationship Problems	1.76 (.62)	2.16 (.86) ***		1.88 (.69)	1.99 (.78)	2.56 (.92) *	2.12 (.70) *
Financial Dependence	2.49 (1.22)	3.51 (1.27) ***		3.15 (1.09)	4.26 (1.20) ***	4.43 (.79) **	3.83 (1.26) ***
Number of Sex Partners	2.22 (2.00)	2.20 (2.58)		2.16 (1.49)	2.84 (2.17)	3.00 (4.53)	4.03 (2.90) ***

Note. Differences were evaluated via one-way ANOVA

* $p < .05$,

** $p < .01$,

*** $p < .001$ compared to controls.