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**The longitudinal association between infant negative emotionality, childhood maltreatment, and ADHD symptoms: A secondary analysis of data from the Fragile Families and Child Wellbeing Study**

**Abstract**

**Background:** Infant temperament predicts harsh parenting, and ADHD symptoms. Moreover, childhood maltreatment has consistently been associated with later ADHD symptoms. We hypothesized that infant negative emotionality predicted both ADHD symptoms and maltreatment, and that there was a bi-directional association between maltreatment experiences and ADHD symptoms.

**Methods:** The study used secondary data from the longitudinal Fragile Families and Child Wellbeing Study (N= 2860). A structural equation model was conducted, using maximum likelihood with robust standard errors. Infant negative emotionality acted as a predictor. Outcome variables were childhood maltreatment and ADHD symptoms at ages 5 and 9.

**Results:** The model demonstrated good fit (RMSEA=.02, CFI=.99, TLI=.96). Infant negative emotionality positively predicted childhood maltreatment at ages 5 and 9, and ADHD symptoms at age 5. Age 5 maltreatment/ ADHD symptoms predicted age 9 ADHD symptoms/ maltreatment. Additionally, both childhood maltreatment and ADHD symptoms at age 5 mediated the association between negative emotionality and childhood maltreatment/ ADHD symptoms at age 9.

**Conclusions:** Given the bidirectional relationship between ADHD and experiences of maltreatment, it is vital to identify early shared risk factors to prevent negative downstream effects and support families at risk. Our study showed that infant negative emotionality, poses one of these risk factors.

*Keywords:* Childhood maltreatment, ADHD, infant temperament, negative emotionality

**Introduction**

Attention deficit/ hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by high levels of inattention and/ or hyperactivity that interfere with everyday functioning. An inattentive, hyperactive or combined subtype can be diagnosed (American Psychiatric Association, 2013)

According to meta-analytic evidence, the prevalence ranges between 6-7% depending on reporter (i.e., parent or teacher) with a higher prevalence for males than females (2.4:1). The inattentive subtype constitutes the most common subtype (Willcutt, 2012).

While ADHD has a high heritability (Faraone & Larsson, 2019), multiple environmental risk factors have been discussed, including experiences of childhood maltreatment (i.e., experiences of abuse or neglect) (Posner et al., 2020) to the extent that it was included into a recently published risk calculator for the development of young adult ADHD (Caye et al., 2019). A meta-analysis showed that in comparison to the general population, people with ADHD have 2.39 times higher odds of having experienced maltreatment with a maltreatment rate of 45.6% amongst people with an ADHD diagnosis (Clayton et al., 2018). The relationship between experiences of adversity, (i.e., having experienced abuse, deprivation, poverty, neglect or trauma) and ADHD seems to be bi-directional: early maltreatment experiences seem to pose a risk factor for the development of ADHD, and ADHD seems to be a risk factor for experiencing subsequent maltreatment.

Evidence for an effect of severe maltreatment on the development of ADHD symptoms and diagnosis comes from the English and Romanian Adoptees Study (ERA). ERA is a longitudinal study that follows a group of Romanian adoptees who experienced severe institutional deprivation (i.e., severe neglect) in orphanages under the Ceausescu regime, and a comparison group of never-institutionalized UK adoptees. The study demonstrated a positive association between the time spent in the orphanage and ADHD symptoms at age 6 (Kreppner et al., 2001). Furthermore, experiences of prolonged deprivation were associated with persistently higher ADHD symptoms from childhood into young adulthood (Sonuga-Barke et al., 2017). In comparison to the general population, the risk of an ADHD diagnosis within the prolonged deprivation group was four times higher in adolescence (19%), and seven times higher (29%) in young adulthood (Kennedy et al., 2016). Due to the unique design of the study as a natural experiment, genetic confounding is unlikely (Rutter et al., 2012), and indeed, common genetic risk factors for neurodevelopmental disorders did not differ between Romanian adoptees who experienced prolonged or low levels of deprivation (Sonuga-Barke et al., 2017).

The effect seems to be less pronounced in general population studies with less severe but more common experiences of maltreatment. A population-based, cross-sectional, co-twin study (Dinkler et al., 2017) including more than 8000 9-year-old twins found that the risk of having more than one neurodevelopmental disorder was seven times higher in maltreated than in non-maltreated individuals. This difference was almost completely explained by shared familial factors. However, the study found a small effect of childhood maltreatment experiences on ADHD *symptoms* (Dinkler et al., 2017). This effect was replicated in a study with over 18,000 adult twins (Capusan et al., 2016), where maltreatment experiences predicted ADHD symptoms. The association was reduced when familial confounding was considered but remained significant. It is possible that familial confounding increases the risk of being maltreated for children with ADHD through gene-environment correlations (Dinkler et al., 2017; Narusyte et al., 2008). One possibility is that the risk for maltreatment by a parent could be increased through genetic influences on child temperamental traits (Dinkler et al., 2017).

A recent meta-analysis showed that ADHD is indeed predicted by various temperamental traits including activity level, negative emotionality and self-regulation (Kostyrka-Allchorne et al., 2020). Temperamental traits in turn have been shown to predict parental stress (Saisto et al., 2008) and harsh parenting (Vitaro et al., 2006). In a sample of 1516 children, childhood temperament (negative emotionality) correlated moderately (r= .27) with harsh parenting at 17 months (Vitaro et al., 2006). In a longitudinal analysis of 12,474 children from the Millennium Cohort Study, high self-regulation at age 3 predicted less harsh parenting at age 5 (Baron & Malmberg, 2019). The direct link between early temperament, harsh parenting or more severe forms of adverse parenting (i.e., abuse or neglect), and ADHD symptoms has, however, not been explored, yet.

By conducting a secondary analysis of data from the longitudinal Fragile Families and Child Wellbeing Study (FFCWS) (Reichman et al., 2001), the current study aims to assess the longitudinal relationship between infant temperament and subsequent experiences of maltreatment and ADHD symptoms. As the study will focus on temperament in infancy, only negative emotionality can be included as a predictor as activity level and self-regulation were not assessed as part of the FFCWS.

1. We hypothesize that infant negative emotionality at 12 months will predict
   1. ADHD symptoms in middle childhood (age 5 and 9 years; replication of previous findings).
   2. The extent of child maltreatment in middle childhood (age 5 and 9 years).
2. To illustrate the bi-directional relationship between the extent of childhood maltreatment and ADHD symptoms, we hypothesize that:
   1. The extent of childhood maltreatment at age 5 years will predict ADHD symptoms at age 9 years
   2. ADHD symptoms at age 5 years will predict childhood maltreatment extent at age 9 years
3. The association between infant negative emotionality at 12-months and ADHD symptoms at age 9 years will be mediated by the extent of child maltreatment at age 5 years.
4. The association between infant negative emotionality at 12-months and childhood maltreatment extent at age 9 years will be mediated by ADHD symptoms at age 5 years

**Methods**

*Sample*

We analyzed data from the FFCWS (Reichman et al., 2001), which follows a birth cohort of N= 4898 children born between 1998 and 2000. The study purposefully oversampled unmarried mothers (n= 3600). Participants were recruited from 75 US hospitals across 20 cities. Data is freely available from Princeton University’s Office of Population Research data archive (<https://opr.princeton.edu/archive/restricted/Default.aspx>). The study design has been described in detail elsewhere (Reichman et al., 2001).

The current study received ethical approval for secondary data analysis from the University of Southampton Ethics Committee (ERGO: 70317), and utilized outcome data from the 1-year (median age 12 months), 5-year (median age 5.08 years) and 9-year follow-up (median age 9.17 years). The 3-year follow-up used a different measure of ADHD symptoms and was therefore not included.

*Measures*

**Negative emotionality in infancy**

Negative emotionality was assessed with three items from the Emotionality, Activity and Sociability Temperament Survey (Mathiesen & Tambs, 1999) using a 5-point Likert scale (1= not at all like my child- to 5= very much like my child)- *Often fusses and cries, gets upset easily* and *reacts intensely when upset*. The study authors’ wording differed slightly from the original version (original: 1= not characteristic or typical of your child to 5= very characteristic or typical of your child). Data was available from N= 4316 resident mothers. Cronbach’s alpha for the scale was . Inter-item correlations fell within an acceptable range (Clark & Watson, 1995) with a mean inter-item correlation of r= .33 (range: r= .26 to r= .393).

**Childhood maltreatment in middle childhood**

The FFCWS assessed childhood maltreatment with selected items from the Conflict Tactics Scale (Straus et al., 1998). This version excludes 8 items assessing severe physical maltreatment. Five items each (15 items in total) were used from the following subscales: psychological aggression (i.e., “*Called him/ her dumb or lazy or some other name like that*”), physical assault (i.e., “*Hit him/ her on the bottom with something like a belt, hairbrush, a stick or some other hard object*”) and neglect (i.e., “*Was so drunk or high that they had a problem taking care of their child*”). All items referred to the past year. The following response options were given: once, twice, 3-5 times, 6-10 times, 11-20 times, more than 20 times, not in the past year, but it happened before, this has never happened. Response options from once to over 20 times were coded 1 to 5. All other options were coded as 0. For the purpose of this study, a compound score was created by summing the ratings of all 15 items to reflect the extent of child maltreatment. Only complete data from the primary caregiver was included (age 5 years: N= 2874, ; age 9 years: N= 2878, ).

**ADHD symptoms at ages 5 and 9 years**

ADHD symptoms at ages 5 and 9 years were assessed with the 11-item Attention Problems subscale of the Child Behavior Checklist (Achenbach, 1992) (i.e., “*Can’t concentrate, can’t pay attention for long*“; Age 5 years: N= 2758, , age 9 years: N= 3244, . The age 5 assessment included four items in the mother survey while 7 additional items were asked during the primary caregiver survey. At age 9 all items were assessed as part of the primary caregiver survey. The percentage of children above the cut-off (≥ 6, Skarphedinsson et al., 2021) is provided in Table 1.

**Covariates**

We controlled for the influence of the following covariates on all outcome variables: sex (1= male, 2= female), low birthweight of under 2500 grams (0= no, 1= yes), presence of physical disabilities (1= yes, 2= no), mother’s age in years, child age at time of mother interview in months, maternal depression (0= no, 1= yes) diagnosed with the Composite International Diagnostic Interview- short form (Kessler et al., 1998), and family income as a measure of socio-economic status. We also accounted for the correlation between childhood maltreatment and ADHD symptoms at each time point.

*Statistical analysis*

A structural equation model was created using MPlus version 8 (Muthén & Muthén, 2017). To account for non-normal distribution of data, the model used maximum likelihood estimation with robust standard errors (MLR). MLR estimates missing data on outcome variables using maximum likelihood estimation with robust standard errors under the missing at random assumption and requires listwise deletion of missing data on predictor variables. Model fit was established via the Root-Mean-Square Error of Approximation (RMSEA< .05 indicates good fit), Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI; CFI/ TLI> .95 indicate good fit) (Geiser, 2012). All model coefficients represent standardized estimates (STDYX for continuous and STDY for categorical variables).

**Results**

Mean, standard deviation, median, and range for all variables of interest are reported in Table 1. As the estimator requires listwise deletion for predictor variables (including covariates), data was available from 2860 participants. The overall model fit was good (RMSEA= .02, CFI= .99, TLI= .96). The model explained 8.4% of variance for ADHD symptoms at age 5 years, 25.3% for ADHD symptoms at age 9 years, 4.5% of childhood maltreatment at age 5 years and 31.5% of variance for childhood maltreatment at age 9 years. The complete model with standardized estimates (STDYX) can be found in Figure 1 and Table 2. The model specification and output can be found in Supplement 1.

INSERT TABLE 1 HERE

**Direct effects**

Negative emotionality at age 12 months was associated with an increased likelihood for higher rates of childhood maltreatment at both ages 5 and 9. It was also significantly associated with increased ADHD symptoms at age 5 years, but not 9 years.

The extent of childhood maltreatment at age 5 years was associated with increased ADHD symptoms at age 9 years, and higher ADHD symptoms at age 5 years predicted higher likelihood for maltreatment at age 9 years.

In addition to cross-lagged effects, we also observed stability effects. ADHD symptoms at age 5 years predicted ADHD symptoms at age 9 years. The extent of childhood maltreatment at age 5 years predicted childhood maltreatment extent at age 9 years. It is worth noting that the stability effects were relatively larger than the cross-lagged effects.

Higher ADHD symptoms at both assessment points were associated with male sex and the presence of maternal depression. ADHD symptoms at age 5 years were additionally associated with the presence of a physical disability, lower maternal age and lower socio-economic status.

Across both assessment points, higher rates of maltreatment were associated with lower maternal age and presence of maternal depression. Maltreatment extent at age 5 years were additionally associated with male sex and lower socio-economic status. Maltreatment extent at age 9 years was additionally associated with the absence of low birth weight and lower child age (see Table 2).

INSERT TABLE 2 HERE

**Indirect effects**

The effect of negative emotionality at age 12 months on ADHD symptoms at age 9 years was mediated by the extent of childhood maltreatment at age 5 years. The effect of negative emotionality at age 12 months on childhood maltreatment extent at age 9 years was mediated by ADHD symptoms at age 5 years.

Negative emotionality at age 12 months further had an indirect effect on ADHD symptoms at age 9 years via ADHD symptoms at age 5 years and an indirect effect on the extent of childhood maltreatment at age 9 years via childhood maltreatment at age 5 years. Indirect effects are shown in Figure 1 and reported in Table 3.

INSERT TABLE 3 HERE

**Discussion**

We hypothesized a direct effect of negative emotionality on the extent of childhood maltreatment and ADHD symptoms, a bi-directional relationship between childhood maltreatment extent and ADHD symptoms, and indirect effects between negative emotionality and i) ADHD symptoms and ii) the extent of childhood maltreatment via i) childhood maltreatment extent and ii) ADHD symptoms. All our hypotheses were confirmed, apart from hypothesis 1a. Negative emotionality did predict ADHD symptoms at age 5, but not 9 years. However, the effect of negative emotionality on ADHD symptoms at 9 years was partially mediated by ADHD symptoms at 5 years.

The main finding from this study is that negative emotionality at age 12 months has an indirect effect on ADHD symptoms at age 9 that is mediated by the extent of maltreatment at age 5, i.e., children who show higher negative emotionality at age 12 months are more likely to experience higher rates of maltreatment at age 5, which in turn increases ADHD symptoms at age 9.

Moreover, infant negative emotionality predicted both ADHD symptoms and child maltreatment extent at age 5 directly, i.e., children with high negative emotionality have a higher risk of experiencing higher rates of maltreatment. Dinkler and colleagues (2017) suggested that higher maltreatment rates in children with neurodevelopmental disorders could be explained by genetically influenced traits that increase a child’s risk of maltreatment by a parent. Negative emotionality shares genetic risk with ADHD (Singh & Waldman, 2010) and might be an early sign or form of externalizing disorder, such as ADHD (Healey et al., 2011). Parent mental ill-health (Ayers et al., 2019) and emotion regulation difficulties (Wang, 2022) are associated with childhood maltreatment. It is possible that parents with ADHD (or at least high impulsivity) are more likely to use harmful conflict tactics, especially in response to a child with behavioural and emotional difficulties (e.g., negative emotionality), and their children are likely to inherit an increased vulnerability to negative emotionality and to later ADHD symptoms (Faraone et al., 2021; Faraone & Larsson, 2019). However, while genetic risk and childhood maltreatment both increase the risk of developing ADHD independently, no interaction between the two has been found, i.e., having a high genetic risk for ADHD and experiencing childhood maltreatment does not increase the risk to develop ADHD over and above the risk posed by each of these factors (He & Li, 2022). The recently proposed double-jeopardy model argues that both, experiences of maltreatment and the presence of a neurodevelopmental disorders such as ADHD, increase the risk for adverse health outcomes, potentially via changes to the stress system- a shared risk pathway (Gajwani & Minnis, 2022). While the effect is small, we were able to show that infant negative emotionality has an enduring effect on childhood maltreatment extent and ADHD symptoms in middle childhood.

The cross-lagged findings show that a small, mutual influence between ADHD symptoms and maltreatment rates over time can be assumed, i.e., controlling for important other risk factors, having higher ADHD symptoms at age 5 increases the risk for a child to be maltreated at age 9 and being maltreated at age 5 leads to higher ADHD symptoms at age 9. Associations between maltreatment and a later, increased risk of ADHD have been shown repeatedly (Craig et al., 2020; Kreppner et al., 2001; Sanderud et al., 2016; Sonuga-Barke et al., 2017).

Our finding regarding ADHD as a risk factor for maltreatment is consistent with results from other studies. For instance, a large longitudinal study (Lugo-Candelas et al., 2020) on 5-15-year-old Puerto Rican children (N= 2,491) showed that ADHD predicted subsequent adverse experiences, particularly parental maladjustment- an effect which was driven by inattentive symptoms. A recent follow-up from the English and Romanian Adoptees Study found that experiences of profound early neglect predicted symptoms of ADHD which in turn predicted bullying victimisation (Rizeq et al., 2022). Taken together, it seems as if ADHD can set children up for adverse experiences within and outside of the family context.

Our results show that the relationship is mutual. The bidirectional relationship between maltreatment experiences and ADHD symptoms might pose a vicious cycle where the severity of ADHD symptoms is maintained through recent adverse experiences.

Not unexpectedly, the largest effects we found in our cross-lagged path model were that ADHD symptoms at age 5 predicted ADHD symptoms at age 9, and the same was true for the extent of maltreatment. This is in line with previous literature and the size of the effects is comparable to results from other cohort studies (Bowling et al., 2018; S. Wang et al., 2021). Previous studies have shown that at least a subset of children with ADHD symptoms has a consistent trajectory of either stable or increasing ADHD symptoms across development (Murray et al., 2019; Walton et al., 2017). High vulnerability and stability regarding ADHD have been linked to genetic (Thapar, 2018), epigenetic (Walton et al., 2017), and environmental factors (Langberg et al., 2008; Sasser et al., 2016). It is therefore not surprising that ADHD scores are correlated substantially across development.

In a similar manner, parenting styles are relatively consistent over time (Dallaire & Weinraub, 2005; Wittig & Rodriguez, 2019), and parents who experienced abuse in their upbringing are more likely to show abusive or neglectful behavior (Greene et al., 2020; van IJzendoorn et al., 2020). Our results show that rates of maltreatment practices also remained stable over time. This may not be surprising, considering that a parent would have to change their approach to conflict and would have to learn and apply a different strategy to solve the conflict.

It should also be noted that the contemporaneous association between the extent of maltreatment experiences and ADHD symptoms was larger than the cross-lagged association over time. This finding is consistent with a recency model where more proximal adverse experiences are thought to have a larger impact on development (Gabard-Durnam & McLaughlin, 2019). This assumption has been examined on a large sample from the Avon Longitudinal Study (N= 7476). The authors tested how well different theoretical models explained the association between different types of adversity and emotional and behavioural problems. The association between abuse and psychopathology was best accounted for by a recency model rather than a sensitive developmental period model (Dunn et al., 2018).

Some of the included covariates seem to pose additional robust risk factors as they increased either maltreatment or ADHD risk across *both* time points. For ADHD, those risk factors were maternal depression and male sex. Both factors have been included in a risk calculator for adult ADHD (Caye et al., 2019). Our data showed that these factors already predict ADHD symptom load across childhood.

In line with previous findings, younger maternal age (de Paúl & Domenech, 2000; Dixon et al., 2005) and maternal depression diagnosis (Choi et al., 2019; Stith et al., 2009) increased the risk for maltreatment across both time points.

It would therefore be vital not only to focus on risk calculators for psychopathology (Caye et al., 2019; Meehan et al., 2020), but on risk calculators for transdiagnostic risk factors, such as childhood maltreatment. We were able to show that negative emotionality in infancy, ADHD symptoms in middle childhood, maternal depression, and age should be included in such a risk calculator.

Some of the included risk factors may be correlated. A study using data from the Avon Longitudinal Study showed that the presence of maternal depression was associated with the presence of other risk factors including younger maternal age and domestic violence. Maternal depression may hence increase the child’s cumulative risk exposure, i.e., maternal depression increases the vulnerability of a child to develop a mental health problem including ADHD (Barker et al., 2012).

The current policies react to childhood maltreatment by temporarily or permanently placing children into out-of-home care (Department of Education, 2021; Drake et al., 2022; Hong et al., 2022). In addition, it would be desirable to also focus efforts on the prevention of childhood maltreatment in the first place as this would considerably reduce the global mental health burden. A meta-analysis of prospective longitudinal studies, for instance, was able to demonstrate that a reduction of maltreatment by 25% could reduce global cases of anxiety and depression by 80 million (Li et al., 2016). Therefore, a variety of prevention and treatment policies and programmes might be needed to address the issue more effectively (Magruder et al., 2017).

The results from our study could inform health professionals who regularly visit new parents at home (i.e., health visitors in the UK) about potential additional support needs of parents from social, educational or health services.

For instance, screening parents for depressive symptoms and stress levels (i.e., in reaction to an infant’s temperament) might be helpful for identifying parents in need of support*.* Whether or not this would have an actual impact on parent behaviour and/ or potential risks for children would need to be evaluated in future studies though.

Our findings further highlight the bivariate relationship between maltreatment and ADHD symptoms. This supports previous findings that found an effect of childhood maltreatment on ADHD symptoms (Capusan et al., 2016; Dinkler et al., 2017; Kennedy et al., 2016; Sonuga-Barke et al., 2017), and findings that children with ADHD are at a higher risk for maltreatment (Hellstrom, 2019; Stern et al., 2018). Overall, the results are in line with recommendations for early identification of ADHD and parenting support in maltreated children (Minnis, 2013) or assessments of adverse experiences as part of ADHD assessments (Sonuga-Barke et al., 2017). It should be emphasized however that ADHD symptoms are represented on a continuum (McLennan, 2016; Sonuga-Barke et al., 2022) and that higher rates of these symptoms do not equal a clinical presentation. Symptoms similar to ADHD can further be observed in trauma-related conditions such as post-traumatic stress disorder including restlessness or hyperactivity (Cohen, 2010).

**Strengths and Limitations**

While this study had clear strengths including the longitudinal design, large sample size and control for relevant confounders, it had a few limitations. The FFCWS did not assess ADHD symptoms or maltreatment at the 12 months follow-up, nor did it assess ADHD symptoms or diagnoses in caregivers at any time point. Hence, it was not possible to control for these influences at the 12 months timepoint.

It stands to question however whether ADHD symptoms can be reliably assessed in infancy. Whereas a previous study reported acceptable psychometric properties in 2-year old children (Brown & Harvey, 2019), comparable data on 12 months olds is missing. While it is possible to assess maltreatment in infants, the prevalence of maltreatment in children below 12 months is with 0.2% very low (Shanahan et al., 2022). Given that the FFCWS study includes quite substantive assessments, it is understandable that less priority was given to the assessment of maltreatment in infancy.

Given the high heritability of ADHD (Faraone & Larsson, 2019) it is further likely that parental ADHD affects ADHD related temperament dimensions in their offspring. Indeed, it has been shown that ADHD symptoms in mothers (Sullivan et al., 2015) and fathers (Auerbach et al., 2008) are associated with temperamental traits in infants. We therefore recommend that future birth cohort studies assess parental ADHD symptoms at baseline. In conjunction with that, maltreatment experiences of parents should be assessed as those have been identified as an antecedent of offspring maltreatment (van IJzendoorn et al., 2020).

**Conclusion**

The bidirectional relationship between ADHD and experiences of maltreatment highlights the need to identify early shared risk factors to prevent negative downstream effects of maltreatment and ADHD symptoms. Understanding these risk factors would enable social and clinical services to better support families at risk. Our study on a large longitudinal sample showed that infant negative emotionality, poses one of these shared risk factors.

**References**

Achenbach, T. M. (1992). *Manual for the child behavior checklist/2-3 and 1992 profile*. Dept. of Psychiatry, University of Vermont.

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®)*. American Psychiatric Pub.

Auerbach, J. G., Berger, A., Atzaba-Poria, N., Arbelle, S., Cypin, N., Friedman, A., & Landau, R. (2008). Temperament at 7, 12, and 25 months in children at familial risk for ADHD. *Infant and Child Development*, *17*(4), 321–338. https://doi.org/10.1002/icd.579

Ayers, S., Bond, R., Webb, R., Miller, P., & Bateson, K. (2019). Perinatal mental health and risk of child maltreatment: A systematic review and meta-analysis. *CHILD ABUSE & NEGLECT*, *98*. https://doi.org/10.1016/j.chiabu.2019.104172

Baron, A., & Malmberg, L.-E. (2019). A vicious or auspicious cycle: The reciprocal relation between harsh parental discipline and children’s self-regulation. *European Journal of Developmental Psychology*, *16*(3), 302–317. https://doi.org/10.1080/17405629.2017.1399875

Bowling, A. B., Tiemeier, H. W., Jaddoe, V. W. V., Barker, E. D., & Jansen, P. W. (2018). ADHD symptoms and body composition changes in childhood: A longitudinal study evaluating directionality of associations. *Pediatric Obesity*, *13*(9), 567–575. https://doi.org/10.1111/ijpo.12288

Brown, H. R., & Harvey, E. A. (2019). Psychometric Properties of ADHD Symptoms in Toddlers. *Journal of Clinical Child and Adolescent Psychology*, *48*(3), 423–439. https://doi.org/10.1080/15374416.2018.1485105

Capusan, A. J., Kuja-Halkola, R., Bendtsen, P., Viding, E., McCrory, E., Marteinsdottir, I., & Larsson, H. (2016). Childhood maltreatment and attention deficit hyperactivity disorder symptoms in adults: A large twin study. *Psychological Medicine*, *46*(12), 2637–2646. https://doi.org/10.1017/S0033291716001021

Caye, A., Agnew-Blais, J., Arseneault, L., Gonçalves, H., Kieling, C., Langley, K., Menezes, A. M. B., Moffitt, T. E., Passos, I. C., Rocha, T. B., Sibley, M. H., Swanson, J. M., Thapar, A., Wehrmeister, F., & Rohde, L. A. (2019). A risk calculator to predict adult attention-deficit/hyperactivity disorder: Generation and external validation in three birth cohorts and one clinical sample. *Epidemiology and Psychiatric Sciences*, *29*, e37. https://doi.org/10.1017/S2045796019000283

Choi, K. W., Houts, R., Arseneault, L., Pariante, C., Sikkema, K. J., & Moffitt, T. E. (2019). Maternal depression in the intergenerational transmission of childhood maltreatment and its sequelae: Testing postpartum effects in a longitudinal birth cohort. *Development and Psychopathology*, *31*(1), 143–156. https://doi.org/10.1017/S0954579418000032

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment*, *7*(3), 309–319. https://doi.org/10.1037/1040-3590.7.3.309

Clayton, K., Lee, J. B., Cheung, K., Theule, J., & Henrikson, B. (2018). Quantifying the Relationship between Attention-Deficit/Hyperactivity Disorder and Experiences of Child Maltreatment: A Meta-Analysis. *Child Abuse Review*, *27*(5), 361–377. https://doi.org/10.1002/car.2530

Cohen, J. A. (2010). Practice Parameter for the Assessment and Treatment of Children and Adolescents With Posttraumatic Stress Disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *49*(4), 414–430. https://doi.org/10.1016/j.jaac.2009.12.020

Craig, S. G., Bondi, B. C., O’Donnell, K. A., Pepler, D. J., & Weiss, M. D. (2020). ADHD and Exposure to Maltreatment in Children and Youth: A Systematic Review of the Past 10 Years. *Current Psychiatry Reports*, *22*(12), 79. https://doi.org/10.1007/s11920-020-01193-w

Dallaire, D. H., & Weinraub, M. (2005). The stability of parenting behaviors over the first 6 years of life. *Early Childhood Research Quarterly*, *20*(2), 201–219. https://doi.org/10.1016/j.ecresq.2005.04.008

de Paúl, J., & Domenech, L. (2000). Childhood history of abuse and child abuse potential in adolescent mothers: A longitudinal study. *Child Abuse & Neglect*, *24*(5), 701–713. https://doi.org/10.1016/S0145-2134(00)00124-1

Department of Education. (2021). *Children looked after in England including adoptions*. https://explore-education-statistics.service.gov.uk/find-statistics/children-looked-after-in-england-including-adoptions/2021#releaseHeadlines-charts

Dinkler, L., Lundström, S., Gajwani, R., Lichtenstein, P., Gillberg, C., & Minnis, H. (2017). Maltreatment-associated neurodevelopmental disorders: A co-twin control analysis. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *58*(6), 691–701. https://doi.org/10.1111/jcpp.12682

Dixon, L., Browne, K., & Hamilton-Giachritsis, C. (2005). Risk factors of parents abused as children: A mediational analysis of the intergenerational continuity of child maltreatment (Part I). *Journal of Child Psychology and Psychiatry*, *46*(1), 47–57. https://doi.org/10.1111/j.1469-7610.2004.00339.x

Drake, B., Fluke, J. D., Kim, H., Orsi, R., & Stubblefield, J. L. (2022). What Proportion of Foster Care Children Do Not Have Child Protective Services Reports? A Preliminary Look. *Child Maltreatment*, *27*(4), 596–604. https://doi.org/10.1177/10775595211033855

Dunn, E. C., Crawford, K. M., Soare, T. W., Button, K. S., Raffeld, M. R., Smith, A. D. A. C., Penton-Voak, I. S., & Munafò, M. R. (2018). Exposure to childhood adversity and deficits in emotion recognition: Results from a large, population-based sample. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *59*(8), 845–854. https://doi.org/10.1111/jcpp.12881

Faraone, S. V., Banaschewski, T., Coghill, D., Zheng, Y., Biederman, J., Bellgrove, M. A., Newcorn, J. H., Gignac, M., Al Saud, N. M., Manor, I., Rohde, L. A., Yang, L., Cortese, S., Almagor, D., Stein, M. A., Albatti, T. H., Aljoudi, H. F., Alqahtani, M. M. J., Asherson, P., … Wang, Y. (2021). The World Federation of ADHD International Consensus Statement: 208 Evidence-based conclusions about the disorder. *Neuroscience and Biobehavioral Reviews*, *128*, 789–818. https://doi.org/10.1016/j.neubiorev.2021.01.022

Faraone, S. V., & Larsson, H. (2019). Genetics of attention deficit hyperactivity disorder. *Molecular Psychiatry*, *24*(4), Article 4. https://doi.org/10.1038/s41380-018-0070-0

Gabard-Durnam, L. J., & McLaughlin, K. A. (2019). Do Sensitive Periods Exist for Exposure to Adversity? *Biological Psychiatry*, *85*(10), 789–791. https://doi.org/10.1016/j.biopsych.2019.03.975

Gajwani, R., & Minnis, H. (2022). Double jeopardy: Implications of neurodevelopmental conditions and adverse childhood experiences for child health. *European Child & Adolescent Psychiatry*. https://doi.org/10.1007/s00787-022-02081-9

Geiser, C. (2012). Linear Structural Equation Models. In *Data Analysis with Mplus*. Guilford Press.

Greene, C. A., Haisley, L., Wallace, C., & Ford, J. D. (2020). Intergenerational effects of childhood maltreatment: A systematic review of the parenting practices of adult survivors of childhood abuse, neglect, and violence. *Clinical Psychology Review*, *80*, 101891. https://doi.org/10.1016/j.cpr.2020.101891

He, Q., & Li, J. J. (2022). A Gene-Environment Interaction Study of Polygenic Scores and Maltreatment on Childhood ADHD. *Research on Child and Adolescent Psychopathology*, *50*(3), 309–319. https://doi.org/10.1007/s10802-021-00873-2

Healey, D. M., Marks, D. J., & Halperin, J. M. (2011). Examining the interplay among negative emotionality, cognitive functioning, and attention deficit/hyperactivity disorder symptom severity. *Journal of the International Neuropsychological Society: JINS*, *17*(3), 502–510. https://doi.org/10.1017/S1355617711000294

Hellstrom, L. (2019). A Systematic Review of Polyvictimization among Children with Attention Deficit Hyperactivity or Autism Spectrum Disorder. *International Journal of Environmental Research and Public Health*, *16*(13), 2280. https://doi.org/10.3390/ijerph16132280

Hong, K., Morelli, N. M., Garcia, J., Duong, J. B., Evans, M. C., Litrownik, A. J., & Villodas, M. T. (2022). Trajectories of adolescent psychopathology among youth who were maltreated and placed in out-of-home care. *Child Abuse & Neglect*, *128*, 105589. https://doi.org/10.1016/j.chiabu.2022.105589

Kennedy, M., Kreppner, J., Knights, N., Kumsta, R., Maughan, B., Golm, D., Rutter, M., Schlotz, W., & Sonuga-Barke, E. J. S. (2016). Early severe institutional deprivation is associated with a persistent variant of adult attention-deficit/hyperactivity disorder: Clinical presentation, developmental continuities and life circumstances in the English and Romanian Adoptees study. *Journal of Child Psychology and Psychiatry*, *57*(10), 1113–1125. https://doi.org/10.1111/jcpp.12576

Kessler, R. C., Andrews, G., Mroczek, D., Ustun, B., & Wittchen, H.-U. (1998). The World Health Organization Composite International Diagnostic Interview short-form (CIDI-SF). *International Journal of Methods in Psychiatric Research*, *7*(4), 171–185. https://doi.org/10.1002/mpr.47

Kostyrka-Allchorne, K., Wass, S. V., & Sonuga-Barke, E. J. S. (2020). Research Review: Do parent ratings of infant negative emotionality and self-regulation predict psychopathology in childhood and adolescence? A systematic review and meta-analysis of prospective longitudinal studies. *Journal of Child Psychology and Psychiatry*, *61*(4), 401–416. https://doi.org/10.1111/jcpp.13144

Kreppner, J. M., O’Connor, T. G., Rutter, M., & English and Romanian Adoptees Study Team. (2001). Can Inattention/Overactivity Be an Institutional Deprivation Syndrome? *Journal of Abnormal Child Psychology*, *29*(6), 513–528. https://doi.org/10.1023/A:1012229209190

Langberg, J. M., Epstein, J. N., Altaye, M., Molina, B. S. G., Arnold, L. E., & Vitiello, B. (2008). The transition to middle school is associated with changes in the developmental trajectory of ADHD symptomatology in young adolescents with ADHD. *Journal of Clinical Child and Adolescent Psychology: The Official Journal for the Society of Clinical Child and Adolescent Psychology, American Psychological Association, Division 53*, *37*(3), 651–663. https://doi.org/10.1080/15374410802148095

Li, M., D’Arcy, C., & Meng, X. (2016). Maltreatment in childhood substantially increases the risk of adult depression and anxiety in prospective cohort studies: Systematic review, meta-analysis, and proportional attributable fractions. *Psychological Medicine*, *46*(4), 717–730. https://doi.org/10.1017/S0033291715002743

Lugo-Candelas, C., Corbeil, T., Wall, M., Posner, J., Bird, H., Canino, G., Fisher, P. W., Suglia, S. F., & Duarte, C. S. (2020). ADHD and risk for subsequent adverse childhood experiences: Understanding the cycle of adversity. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*. https://doi.org/10.1111/jcpp.13352

Magruder, K. M., McLaughlin, K. A., & Elmore Borbon, D. L. (2017). Trauma is a public health issue. *European Journal of Psychotraumatology*, *8*(1), 1375338. https://doi.org/10.1080/20008198.2017.1375338

Mathiesen, K., & Tambs, K. (1999). The EAS Temperament Questionnaire—Factor Structure, Age Trends, Reliability, and Stability in a Norwegian Sample. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *40*, 431–439. https://doi.org/10.1111/1469-7610.00460

McLennan, J. D. (2016). Understanding attention deficit hyperactivity disorder as a continuum. *Canadian Family Physician*, *62*(12), 979–982.

Meehan, A. J., Latham, R. M., Arseneault, L., Stahl, D., Fisher, H. L., & Danese, A. (2020). Developing an individualized risk calculator for psychopathology among young people victimized during childhood: A population-representative cohort study. *Journal of Affective Disorders*, *262*, 90–98. https://doi.org/10.1016/j.jad.2019.10.034

Minnis, H. (2013). Maltreatment-Associated Psychiatric Problems: An Example of Environmentally Triggered ESSENCE? *The Scientific World Journal*, *2013*, 1–5. https://doi.org/10.1155/2013/148468

Murray, A. L., Booth, T., Eisner, M., Auyeung, B., Murray, G., & Ribeaud, D. (2019). Sex differences in ADHD trajectories across childhood and adolescence. *Developmental Science*, *22*(1), e12721. https://doi.org/10.1111/desc.12721

Muthén, L. K., & Muthén, B. O. (2017). *Mplus: Statistical Analysis with Latent Variables: User’s Guide (Version 8)*. Los Angeles.

Narusyte, J., Neiderhiser, J. M., D’Onofrio, B. M., Reiss, D., Spotts, E. L., Ganiban, J., & Lichtenstein, P. (2008). Testing different types of genotype-environment correlation: An extended children-of-twins model. *Developmental Psychology*, *44*(6), 1591–1603. https://doi.org/10.1037/a0013911

Posner, J., Polanczyk, G. V., & Sonuga-Barke, E. (2020). Attention-deficit hyperactivity disorder. *Lancet (London, England)*, *395*(10222), 450–462. https://doi.org/10.1016/S0140-6736(19)33004-1

Reichman, N. E., Teitler, J. O., Garfinkel, I., & McLanahan, S. S. (2001). Fragile Families: Sample and design. *Children and Youth Services Review*, *23*(4–5), 303–326. https://doi.org/10.1016/S0190-7409(01)00141-4

Rizeq, J., Kennedy, M., Kreppner, J., Maughan, B., & Sonuga-Barke, E. (2022). Understanding the prospective associations between neuro-developmental problems, bullying victimization, and mental health: Lessons from a longitudinal study of institutional deprivation. *Development and Psychopathology*, 1–10. https://doi.org/10.1017/S095457942200089X

Rutter, M., Kumsta, R., Schlotz, W., & Sonuga-Barke, E. (2012). Longitudinal Studies Using a “Natural Experiment” Design: The Case of Adoptees From Romanian Institutions. *Journal of the American Academy of Child & Adolescent Psychiatry*, *51*(8), 762–770. https://doi.org/10.1016/j.jaac.2012.05.011

Saisto, T., Salmela-Aro, K., Nurmi, J.-E., & HalmesmÄki, E. (2008). Longitudinal study on the predictors of parental stress in mothers and fathers of toddlers. *Journal of Psychosomatic Obstetrics & Gynecology*, *29*(3), 219–228.

Sanderud, K., Murphy, S., & Elklit, A. (2016). Child maltreatment and ADHD symptoms in a sample of young adults. *European Journal of Psychotraumatology*, *7*, 32061. https://doi.org/10.3402/ejpt.v7.32061

Sasser, T. R., Kalvin, C. B., & Bierman, K. L. (2016). Developmental trajectories of clinically significant attention-deficit/hyperactivity disorder (ADHD) symptoms from grade 3 through 12 in a high-risk sample: Predictors and outcomes. *Journal of Abnormal Psychology*, *125*(2), 207–219. https://doi.org/10.1037/abn0000112

Shanahan, M. E., Austin, A. E., & Berkoff, M. C. (2022). Prevalence of Injuries Among Medicaid Enrolled Infants Prior to Child Abuse and Neglect. *Child Maltreatment*, *27*(2), 218–224. https://doi.org/10.1177/10775595211031651

Singh, A. L., & Waldman, I. D. (2010). The etiology of associations between negative emotionality and childhood externalizing disorders. *Journal of Abnormal Psychology*, *119*(2), 376–388. https://doi.org/10.1037/a0019342

Skarphedinsson, G., Jarbin, H., Andersson, M., & Ivarsson, T. (2021). Diagnostic efficiency and validity of the DSM-oriented Child Behavior Checklist and Youth Self-Report scales in a clinical sample of Swedish youth. *PLOS ONE*, *16*(7), e0254953. https://doi.org/10.1371/journal.pone.0254953

Sonuga-Barke, E. J., Kennedy, M., Kumsta, R., Knights, N., Golm, D., Rutter, M., Maughan, B., Schlotz, W., & Kreppner, J. (2017). Child-to-adult neurodevelopmental and mental health trajectories after early life deprivation: The young adult follow-up of the longitudinal English and Romanian Adoptees study. *The Lancet*, *389*(10078), 1539–1548.

Sonuga-Barke, E. J. S., Becker, S. P., Bölte, S., Castellanos, F. X., Franke, B., Newcorn, J. H., Nigg, J. T., Rohde, L. A., & Simonoff, E. (2022). Annual Research Review: Perspectives on progress in ADHD science - from characterization to cause. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*. https://doi.org/10.1111/jcpp.13696

Stern, A., Agnew-Blais, J., Danese, A., Fisher, H. L., Jaffee, S. R., Matthews, T., Polanczyk, G. V., & Arseneault, L. (2018). Associations between abuse/neglect and ADHD from childhood to young adulthood: A prospective nationally-representative twin study. *Child Abuse & Neglect*, *81*, 274–285. https://doi.org/10.1016/j.chiabu.2018.04.025

Stith, S. M., Liu, T., Davies, L. C., Boykin, E. L., Alder, M. C., Harris, J. M., Som, A., McPherson, M., & Dees, J. E. M. E. G. (2009). Risk factors in child maltreatment: A meta-analytic review of the literature. *Aggression and Violent Behavior*, *14*(1), 13–29. https://doi.org/10.1016/j.avb.2006.03.006

Straus, M. A., Hamby, S. L., Finkelhor, D., Moore, D. W., & Runyan, D. (1998). Identification of child maltreatment with the parent-child Conflict Tactics Scales: Development and psychometric data for a national sample of American parents. *Child Abuse & Neglect*, *22*(4), 249–270. https://doi.org/10.1016/S0145-2134(97)00174-9

Sullivan, E. L., Holton, K. F., Nousen, E. K., Barling, A. N., Sullivan, C. A., Propper, C. B., & Nigg, J. T. (2015). Early identification of ADHD risk via infant temperament and emotion regulation: A pilot study. *Journal of Child Psychology and Psychiatry*, *56*(9), 949–957. https://doi.org/10.1111/jcpp.12426

Thapar, A. (2018). Discoveries on the Genetics of ADHD in the 21st Century: New Findings and Their Implications. *The American Journal of Psychiatry*, *175*(10), 943–950. https://doi.org/10.1176/appi.ajp.2018.18040383

van IJzendoorn, M. H., Bakermans-Kranenburg, M. J., Coughlan, B., & Reijman, S. (2020). Annual Research Review: Umbrella synthesis of meta-analyses on child maltreatment antecedents and interventions: differential susceptibility perspective on risk and resilience. *Journal of Child Psychology and Psychiatry*, *61*(3), 272–290. https://doi.org/10.1111/jcpp.13147

Vitaro, F., Barker, E. D., Boivin, M., Brendgen, M., & Tremblay, R. E. (2006). Do early difficult temperament and harsh parenting differentially predict reactive and proactive aggression? *Journal of Abnormal Child Psychology*, *34*(5), 681–691.

Walton, E., Pingault, J.-B., Cecil, C. a. M., Gaunt, T. R., Relton, C. L., Mill, J., & Barker, E. D. (2017). Epigenetic profiling of ADHD symptoms trajectories: A prospective, methylome-wide study. *Molecular Psychiatry*, *22*(2), 250–256. https://doi.org/10.1038/mp.2016.85

Wang, S., Shi, X., Wang, Z., Li, Z., Wang, A., Jiang, L., & Fan, F. (2021). Reciprocal relations between sleep and internalizing and externalizing problems: A cohort study of Chinese adolescents. *Current Psychology*. https://doi.org/10.1007/s12144-021-02373-4

Wang, X. (2022). Intergenerational effects of childhood maltreatment: The roles of parents’ emotion regulation and mentalization. *Child Abuse & Neglect*, *128*, 104940. https://doi.org/10.1016/j.chiabu.2021.104940

Willcutt, E. G. (2012). The Prevalence of DSM-IV Attention-Deficit/Hyperactivity Disorder: A Meta-Analytic Review. *Neurotherapeutics*, *9*(3), 490–499. https://doi.org/10.1007/s13311-012-0135-8

Wittig, S. M. O., & Rodriguez, C. M. (2019). Emerging Behavior Problems: Bidirectional Relations between Maternal and Paternal Parenting Styles with Infant Temperament. *Developmental Psychology*, *55*(6), 1199–1210. <https://doi.org/10.1037/dev0000707>

Figure 1: Coefficients represent standardized estimates (STDYX;   
\* p<.05, \*\* p<.01, \*\*\* p<.001). Significant direct effects are represented by solid lines, insignificant effects are represented by dashed lines. Red lines represent significant indirect effects.

Acronyms: ADHD symptoms: attention deficit/ hyperactivity symptoms, Age C: Child age, Age M: Age of the mother, LBW: Low birth weight, MD: Maternal depression, PD: Physical disability, SES: Socio-economic status.

Diagram, schematic

Description automatically generated

Table 1. Descriptive statistics

SD= standard deviation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Time point** | **Mean (SD)** | **Median** | **Range** | **ADHD symptoms**  **above cutoff (≥ 6)** |
| Negative emotionality | 1 year | 2.81 (1.05) | 2.67 | 1- 5 |  |
| Childhood maltreatment | 5 years | 14.60 (9.17) | 14.00 | 0- 49 |  |
|  | 9 years | 11.37 (9.08) | 10.00 | 0- 52 |  |
| ADHD symptoms | 5 years | 2.79 (2.73) | 2.00 | 0- 17 | 14.64% |
|  | 9 years | 3.01 (3.24) | 2.00 | 0- 22 | 18.74% |

Table 2. Direct effects and correlations of variables of interests and covariates.

Maternal age, depression, socio-economic status and child age were measured at the same time as the outcome variables. Correlations are between variables assessed at the same time point. Continuous predictors have been STDYX standardized, categorical predictors have been STDY standardized.

SE= standard error

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **ADHD symptoms** |  | **Maltreatment** |  |
|  | 5 years | 9 years | 5 years | 9 years |
| **Direct effects variables of interest** |  |  |  |  |
| Negative emotionality | **.134\*\*\***  **SE= .021** | .006  SE= .018 | **.091\*\*\***  **SE= .021** | **.041\***  **SE= .019** |
| ADHD symptoms | -- | **.448\*\*\***  **SE= .023** | -- | **.050\***  **SE= .022** |
| Maltreatment | -- | **.017\***  **SE= .007** | -- | **.510\*\*\***  **SE= .023** |
| **Direct effects of covariates** |  |  |  |  |
| Sex | **-.223\*\*\***  **SE= .039** | **-.231\*\*\***  **SE= .035** | **-.148\*\*\***  **SE= .040** | -.033  SE= .036 |
| Low birth weight | .051  SE= .077 | .028  SE= .062 | -.046  SE= .068 | **-.126\***  **SE= .058** |
| Physical disability | **-.493\*\***  **SE= .171** | .104  SE= .106 | .142  SE= .152 | .107  SE= .130 |
| Age mother | **-.061\*\***  **SE= .022** | -.012  SE= .018 | **-.100\*\*\***  **SE= .021** | **-.038\***  **SE= .018** |
| Age child | -.027  SE= .023 | .006  SE= .018 | -.005  SE= .022 | **-.049\*\***  **SE= .018** |
| Socio-economic status | **-.058\***  **SE= .023** | -.014  SE= .018 | **-.072\*\*\***  **SE= .018** | .003  SE= .015 |
| Maternal depression | **.508\*\*\***  **SE= .078** | **.219\*\*\***  **SE= .059** | **.235\*\*\***  **SE= .064** | **.299\*\*\***  **SE= .060** |
| **Correlations** |  |  |  |  |
| ADHD symptoms | -- | -- | **.229\*\*\***  **SE= .021** | **.253\*\*\***  **SE= .026** |
| Maltreatment | **.229\*\*\***  **SE= .021** | **.253\*\*\***  **SE= .026** | -- | -- |

Table 3. Indirect effects

SE= standard error

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Predictor**  Age 12 months | **Mediator**  Age 5 years | **Outcome**  age 9 years | **Estimator (SE)**  (STDYX standardization) | **p-value** |
| Negative emotionality | Childhood maltreatment | ADHD symptoms | .004 (.002) | .030 |
| Negative emotionality | ADHD symptoms | ADHD symptoms | .060 (.010) | <.001 |
| Negative emotionality | Childhood maltreatment | Childhood maltreatment | .047 (.011) | <.001 |
| Negative emotionality | ADHD symptoms | Childhood maltreatment | .007 (.003) | .028 |

Appendix

Mplus VERSION 8 (Mac)

MUTHEN & MUTHEN

11/24/2022 6:05 PM

INPUT INSTRUCTIONS

TITLE: Temperament Paper Analysis

DATA: FILE IS 241122mplus2.dat;

VARIABLE:

NAMES ARE

idnum

csex

lbw

pd

mage4

cage4

mdep4

mage5

cage5

mdep5

ADHD4

ADHD5

NE

CM4

CM5

sesk4

sesk5;

USEVARIABLES ARE

idnum

csex

lbw

pd

mage4

cage4

mdep4

mage5

cage5

mdep5

ADHD4

ADHD5

NE

CM4

CM5

sesk4

sesk5;

IDVARIABLE IS idnum;

MISSING ARE ALL (-99);

ANALYSIS:

ESTIMATOR = MLR;

MODEL:

!DIRECT EFFECTS:

ADHD5 ON ADHD4 CM4 NE ;

CM5 ON ADHD4 CM4 NE;

ADHD4 ON NE;

CM4 ON NE;

!CONTROL VARIABLES;

ADHD4 ON csex lbw pd mage4 cage4 mdep4 sesk4;

ADHD5 ON csex lbw pd mage5 cage5 sesk5 mdep5;

CM4 ON csex lbw pd mage4 cage4 mdep4 sesk4;

CM5 ON csex lbw pd mage5 cage5 sesk5 mdep5;

!CORRELATIONS:

ADHD4 WITH CM4;

ADHD5 WITH CM5;

MODEL INDIRECT:

ADHD5 IND ADHD4 NE;

CM5 IND CM4 NE;

ADHD5 IND CM4 NE;

CM5 IND ADHD4 NE;

OUTPUT: STANDARDIZED; MODINDICES;

\*\*\* WARNING

Data set contains cases with missing on all variables.

These cases were not included in the analysis.

Number of cases with missing on all variables: 1

\*\*\* WARNING

Data set contains cases with missing on x-variables.

These cases were not included in the analysis.

Number of cases with missing on x-variables: 1936

\*\*\* WARNING

Data set contains cases with missing on all variables except

x-variables. These cases were not included in the analysis.

Number of cases with missing on all variables except x-variables: 101

3 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS

Temperament Paper Analysis

SUMMARY OF ANALYSIS

Number of groups 1

Number of observations 2860

Number of dependent variables 4

Number of independent variables 12

Number of continuous latent variables 0

Observed dependent variables

Continuous

ADHD4 ADHD5 CM4 CM5

Observed independent variables

CSEX LBW PD MAGE4 CAGE4 MDEP4

MAGE5 CAGE5 MDEP5 NE SESK4 SESK5

Variables with special functions

ID variable IDNUM

Estimator MLR

Information matrix OBSERVED

Maximum number of iterations 1000

Convergence criterion 0.500D-04

Maximum number of steepest descent iterations 20

Maximum number of iterations for H1 2000

Convergence criterion for H1 0.100D-03

Input data file(s)

241122mplus2.dat

Input data format FREE

SUMMARY OF DATA

Number of missing data patterns 14

COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value 0.100

PROPORTION OF DATA PRESENT

Covariance Coverage

ADHD4 ADHD5 CM4 CM5 CSEX

\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_

ADHD4 0.762

ADHD5 0.707 0.933

CM4 0.735 0.727 0.787

CM5 0.626 0.814 0.646 0.830

CSEX 0.762 0.933 0.787 0.830 1.000

LBW 0.762 0.933 0.787 0.830 1.000

PD 0.762 0.933 0.787 0.830 1.000

MAGE4 0.762 0.933 0.787 0.830 1.000

CAGE4 0.762 0.933 0.787 0.830 1.000

MDEP4 0.762 0.933 0.787 0.830 1.000

MAGE5 0.762 0.933 0.787 0.830 1.000

CAGE5 0.762 0.933 0.787 0.830 1.000

MDEP5 0.762 0.933 0.787 0.830 1.000

NE 0.762 0.933 0.787 0.830 1.000

SESK4 0.762 0.933 0.787 0.830 1.000

SESK5 0.762 0.933 0.787 0.830 1.000

Covariance Coverage

LBW PD MAGE4 CAGE4 MDEP4

\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_

LBW 1.000

PD 1.000 1.000

MAGE4 1.000 1.000 1.000

CAGE4 1.000 1.000 1.000 1.000

MDEP4 1.000 1.000 1.000 1.000 1.000

MAGE5 1.000 1.000 1.000 1.000 1.000

CAGE5 1.000 1.000 1.000 1.000 1.000

MDEP5 1.000 1.000 1.000 1.000 1.000

NE 1.000 1.000 1.000 1.000 1.000

SESK4 1.000 1.000 1.000 1.000 1.000

SESK5 1.000 1.000 1.000 1.000 1.000

Covariance Coverage

MAGE5 CAGE5 MDEP5 NE SESK4

\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_

MAGE5 1.000

CAGE5 1.000 1.000

MDEP5 1.000 1.000 1.000

NE 1.000 1.000 1.000 1.000

SESK4 1.000 1.000 1.000 1.000 1.000

SESK5 1.000 1.000 1.000 1.000 1.000

Covariance Coverage

SESK5

\_\_\_\_\_\_\_\_

SESK5 1.000

UNIVARIATE SAMPLE STATISTICS

UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

Variable/ Mean/ Skewness/ Minimum/ % with Percentiles

Sample Size Variance Kurtosis Maximum Min/Max 20%/60% 40%/80% Median

ADHD4 2.785 1.402 0.000 22.87% 0.000 2.000 2.000

2178.000 7.467 2.520 17.000 0.09% 3.000 5.000

ADHD5 3.009 1.549 0.000 25.48% 0.000 1.000 2.000

2669.000 10.529 3.034 22.000 0.07% 3.000 5.000

CM4 14.602 0.568 0.000 4.89% 6.000 12.000 14.000

2251.000 84.123 0.127 49.000 0.09% 16.000 22.000

CM5 11.374 1.039 0.000 7.79% 3.000 7.000 10.000

2374.000 82.496 0.993 52.000 0.04% 12.000 18.000

CSEX 1.481 0.074 1.000 51.85% 1.000 1.000 1.000

2860.000 0.250 -1.994 2.000 48.15% 2.000 2.000

LBW 0.094 2.774 0.000 90.56% 0.000 0.000 0.000

2860.000 0.085 5.697 1.000 9.44% 0.000 0.000

PD 1.977 -6.302 1.000 2.34% 2.000 2.000 2.000

2860.000 0.023 37.711 2.000 97.66% 2.000 2.000

MAGE4 30.204 0.787 20.000 0.49% 25.000 27.000 29.000

2860.000 36.265 -0.109 50.000 0.14% 31.000 35.000

CAGE4 61.537 1.002 57.000 0.14% 59.000 60.000 61.000

2860.000 7.086 0.869 72.000 0.10% 61.000 64.000

MDEP4 0.114 2.424 0.000 88.57% 0.000 0.000 0.000

2860.000 0.101 3.875 1.000 11.43% 0.000 0.000

MAGE5 34.363 0.779 23.000 0.14% 29.000 31.000 33.000

2860.000 36.240 -0.106 56.000 0.03% 35.000 40.000

CAGE5 112.269 1.296 104.000 0.03% 109.000 110.000 111.000

2860.000 18.241 1.763 130.000 0.10% 112.000 115.000

MDEP5 0.122 2.315 0.000 87.83% 0.000 0.000 0.000

2860.000 0.107 3.357 1.000 12.17% 0.000 0.000

NE 2.809 0.272 1.000 5.28% 2.000 2.333 2.667

2860.000 1.103 -0.651 5.000 5.07% 3.000 3.667

SESK4 38.435 5.251 0.000 0.66% 9.720 20.000 26.000

2860.000 2051.708 55.530 800.000 0.03% 35.000 56.000

SESK5 45.628 3.721 0.000 1.22% 13.206 25.000 32.000

2860.000 2389.636 25.253 600.000 0.07% 40.000 70.000

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 46

Loglikelihood

H0 Value -28024.322

H0 Scaling Correction Factor 1.1633

for MLR

H1 Value -28005.790

H1 Scaling Correction Factor 1.1207

for MLR

Information Criteria

Akaike (AIC) 56140.645

Bayesian (BIC) 56414.740

Sample-Size Adjusted BIC 56268.581

(n\* = (n + 2) / 24)

Chi-Square Test of Model Fit

Value 37.140\*

Degrees of Freedom 16

P-Value 0.0020

Scaling Correction Factor 0.9980

for MLR

\* The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used

for chi-square difference testing in the regular way. MLM, MLR and WLSM

chi-square difference testing is described on the Mplus website. MLMV, WLSMV,

and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.021

90 Percent C.I. 0.012 0.031

Probability RMSEA <= .05 1.000

CFI/TLI

CFI 0.988

TLI 0.960

Chi-Square Test of Model Fit for the Baseline Model

Value 1842.386

Degrees of Freedom 54

P-Value 0.0000

SRMR (Standardized Root Mean Square Residual)

Value 0.009

MODEL RESULTS

Two-Tailed

Estimate S.E. Est./S.E. P-Value

ADHD5 ON

ADHD4 0.532 0.029 18.198 0.000

CM4 0.017 0.007 2.454 0.014

NE 0.020 0.057 0.345 0.730

CSEX -0.748 0.114 -6.569 0.000

LBW 0.091 0.200 0.453 0.651

PD 0.339 0.346 0.979 0.328

MAGE5 -0.006 0.009 -0.672 0.502

CAGE5 0.005 0.014 0.344 0.731

SESK5 -0.001 0.001 -0.797 0.426

MDEP5 0.711 0.190 3.734 0.000

CM5 ON

ADHD4 0.165 0.072 2.275 0.023

CM4 0.510 0.023 22.564 0.000

NE 0.354 0.161 2.206 0.027

CSEX -0.301 0.324 -0.928 0.354

LBW -1.139 0.531 -2.146 0.032

PD 0.972 1.182 0.822 0.411

MAGE5 -0.057 0.027 -2.129 0.033

CAGE5 -0.104 0.039 -2.670 0.008

SESK5 0.000 0.003 0.170 0.865

MDEP5 2.709 0.547 4.954 0.000

ADHD4 ON

NE 0.347 0.055 6.327 0.000

CSEX -0.608 0.109 -5.606 0.000

LBW 0.138 0.209 0.661 0.509

PD -1.343 0.469 -2.863 0.004

MAGE4 -0.028 0.010 -2.813 0.005

CAGE4 -0.027 0.023 -1.166 0.244

MDEP4 1.384 0.220 6.294 0.000

SESK4 -0.003 0.001 -2.517 0.012

CM4 ON

NE 0.795 0.181 4.398 0.000

CSEX -1.358 0.368 -3.686 0.000

LBW -0.424 0.622 -0.681 0.496

PD 1.303 1.392 0.936 0.349

MAGE4 -0.152 0.032 -4.767 0.000

CAGE4 -0.019 0.074 -0.250 0.802

MDEP4 2.154 0.587 3.668 0.000

SESK4 -0.015 0.004 -4.087 0.000

ADHD4 WITH

CM4 5.353 0.546 9.805 0.000

ADHD5 WITH

CM5 5.310 0.581 9.143 0.000

Intercepts

ADHD4 7.814 1.754 4.455 0.000

ADHD5 1.319 1.727 0.764 0.445

CM4 17.927 5.427 3.303 0.001

CM5 14.405 5.205 2.768 0.006

Residual Variances

ADHD4 6.810 0.296 23.005 0.000

ADHD5 7.859 0.396 19.833 0.000

CM4 80.469 2.494 32.269 0.000

CM5 56.233 2.135 26.335 0.000

STANDARDIZED MODEL RESULTS

STDYX Standardization

Two-Tailed

Estimate S.E. Est./S.E. P-Value

ADHD5 ON

ADHD4 0.448 0.023 19.180 0.000

CM4 0.048 0.020 2.446 0.014

NE 0.006 0.018 0.345 0.730

CSEX -0.115 0.017 -6.596 0.000

LBW 0.008 0.018 0.453 0.651

PD 0.016 0.016 0.980 0.327

MAGE5 -0.012 0.018 -0.672 0.502

CAGE5 0.006 0.018 0.345 0.730

SESK5 -0.014 0.018 -0.797 0.425

MDEP5 0.072 0.019 3.720 0.000

CM5 ON

ADHD4 0.050 0.022 2.291 0.022

CM4 0.517 0.019 26.659 0.000

NE 0.041 0.019 2.211 0.027

CSEX -0.017 0.018 -0.927 0.354

LBW -0.037 0.017 -2.146 0.032

PD 0.016 0.020 0.822 0.411

MAGE5 -0.038 0.018 -2.128 0.033

CAGE5 -0.049 0.018 -2.662 0.008

SESK5 0.003 0.015 0.170 0.865

MDEP5 0.098 0.020 4.933 0.000

ADHD4 ON

NE 0.134 0.021 6.414 0.000

CSEX -0.111 0.019 -5.737 0.000

LBW 0.015 0.022 0.662 0.508

PD -0.075 0.026 -2.841 0.004

MAGE4 -0.061 0.022 -2.813 0.005

CAGE4 -0.027 0.023 -1.170 0.242

MDEP4 0.162 0.025 6.476 0.000

SESK4 -0.058 0.023 -2.478 0.013

CM4 ON

NE 0.091 0.021 4.429 0.000

CSEX -0.074 0.020 -3.699 0.000

LBW -0.013 0.020 -0.681 0.496

PD 0.021 0.023 0.933 0.351

MAGE4 -0.100 0.021 -4.767 0.000

CAGE4 -0.005 0.022 -0.250 0.802

MDEP4 0.075 0.020 3.667 0.000

SESK4 -0.072 0.018 -3.944 0.000

ADHD4 WITH

CM4 0.229 0.021 10.768 0.000

ADHD5 WITH

CM5 0.253 0.026 9.896 0.000

Intercepts

ADHD4 2.865 0.633 4.527 0.000

ADHD5 0.407 0.534 0.762 0.446

CM4 1.953 0.592 3.301 0.001

CM5 1.590 0.576 2.758 0.006

Residual Variances

ADHD4 0.916 0.013 70.488 0.000

ADHD5 0.747 0.020 37.130 0.000

CM4 0.955 0.008 118.687 0.000

CM5 0.685 0.019 35.913 0.000

STDY Standardization

Two-Tailed

Estimate S.E. Est./S.E. P-Value

ADHD5 ON

ADHD4 0.448 0.023 19.180 0.000

CM4 0.048 0.020 2.446 0.014

NE 0.006 0.018 0.345 0.730

CSEX -0.231 0.035 -6.596 0.000

LBW 0.028 0.062 0.453 0.651

PD 0.104 0.106 0.981 0.326

MAGE5 -0.002 0.003 -0.672 0.502

CAGE5 0.001 0.004 0.345 0.730

SESK5 0.000 0.000 -0.798 0.425

MDEP5 0.219 0.059 3.732 0.000

CM5 ON

ADHD4 0.050 0.022 2.291 0.022

CM4 0.517 0.019 26.659 0.000

NE 0.039 0.018 2.211 0.027

CSEX -0.033 0.036 -0.927 0.354

LBW -0.126 0.058 -2.150 0.032

PD 0.107 0.130 0.823 0.411

MAGE5 -0.006 0.003 -2.129 0.033

CAGE5 -0.011 0.004 -2.665 0.008

SESK5 0.000 0.000 0.170 0.865

MDEP5 0.299 0.060 4.961 0.000

ADHD4 ON

NE 0.127 0.020 6.429 0.000

CSEX -0.223 0.039 -5.737 0.000

LBW 0.051 0.077 0.662 0.508

PD -0.493 0.171 -2.881 0.004

MAGE4 -0.010 0.004 -2.815 0.005

CAGE4 -0.010 0.009 -1.170 0.242

MDEP4 0.508 0.078 6.542 0.000

SESK4 -0.001 0.001 -2.516 0.012

CM4 ON

NE 0.087 0.020 4.434 0.000

CSEX -0.148 0.040 -3.699 0.000

LBW -0.046 0.068 -0.681 0.496

PD 0.142 0.152 0.935 0.350

MAGE4 -0.017 0.003 -4.775 0.000

CAGE4 -0.002 0.008 -0.250 0.802

MDEP4 0.235 0.064 3.680 0.000

SESK4 -0.002 0.000 -4.105 0.000

ADHD4 WITH

CM4 0.229 0.021 10.768 0.000

ADHD5 WITH

CM5 0.253 0.026 9.896 0.000

Intercepts

ADHD4 2.865 0.633 4.527 0.000

ADHD5 0.407 0.534 0.762 0.446

CM4 1.953 0.592 3.301 0.001

CM5 1.590 0.576 2.758 0.006

Residual Variances

ADHD4 0.916 0.013 70.488 0.000

ADHD5 0.747 0.020 37.130 0.000

CM4 0.955 0.008 118.687 0.000

CM5 0.685 0.019 35.913 0.000

STD Standardization

Two-Tailed

Estimate S.E. Est./S.E. P-Value

ADHD5 ON

ADHD4 0.532 0.029 18.198 0.000

CM4 0.017 0.007 2.454 0.014

NE 0.020 0.057 0.345 0.730

CSEX -0.748 0.114 -6.569 0.000

LBW 0.091 0.200 0.453 0.651

PD 0.339 0.346 0.979 0.328

MAGE5 -0.006 0.009 -0.672 0.502

CAGE5 0.005 0.014 0.344 0.731

SESK5 -0.001 0.001 -0.797 0.426

MDEP5 0.711 0.190 3.734 0.000

CM5 ON

ADHD4 0.165 0.072 2.275 0.023

CM4 0.510 0.023 22.564 0.000

NE 0.354 0.161 2.206 0.027

CSEX -0.301 0.324 -0.928 0.354

LBW -1.139 0.531 -2.146 0.032

PD 0.972 1.182 0.822 0.411

MAGE5 -0.057 0.027 -2.129 0.033

CAGE5 -0.104 0.039 -2.670 0.008

SESK5 0.000 0.003 0.170 0.865

MDEP5 2.709 0.547 4.954 0.000

ADHD4 ON

NE 0.347 0.055 6.327 0.000

CSEX -0.608 0.109 -5.606 0.000

LBW 0.138 0.209 0.661 0.509

PD -1.343 0.469 -2.863 0.004

MAGE4 -0.028 0.010 -2.813 0.005

CAGE4 -0.027 0.023 -1.166 0.244

MDEP4 1.384 0.220 6.294 0.000

SESK4 -0.003 0.001 -2.517 0.012

CM4 ON

NE 0.795 0.181 4.398 0.000

CSEX -1.358 0.368 -3.686 0.000

LBW -0.424 0.622 -0.681 0.496

PD 1.303 1.392 0.936 0.349

MAGE4 -0.152 0.032 -4.767 0.000

CAGE4 -0.019 0.074 -0.250 0.802

MDEP4 2.154 0.587 3.668 0.000

SESK4 -0.015 0.004 -4.087 0.000

ADHD4 WITH

CM4 5.353 0.546 9.805 0.000

ADHD5 WITH

CM5 5.310 0.581 9.143 0.000

Intercepts

ADHD4 7.814 1.754 4.455 0.000

ADHD5 1.319 1.727 0.764 0.445

CM4 17.927 5.427 3.303 0.001

CM5 14.405 5.205 2.768 0.006

Residual Variances

ADHD4 6.810 0.296 23.005 0.000

ADHD5 7.859 0.396 19.833 0.000

CM4 80.469 2.494 32.269 0.000

CM5 56.233 2.135 26.335 0.000

R-SQUARE

Observed Two-Tailed

Variable Estimate S.E. Est./S.E. P-Value

ADHD4 0.084 0.013 6.501 0.000

ADHD5 0.253 0.020 12.551 0.000

CM4 0.045 0.008 5.547 0.000

CM5 0.315 0.019 16.537 0.000

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.543E-07

(ratio of smallest to largest eigenvalue)

TOTAL, TOTAL INDIRECT, SPECIFIC INDIRECT, AND DIRECT EFFECTS

Two-Tailed

Estimate S.E. Est./S.E. P-Value

Effects from NE to ADHD5

Sum of indirect 0.198 0.031 6.382 0.000

Specific indirect

ADHD5

ADHD4

NE 0.185 0.030 6.148 0.000

ADHD5

CM4

NE 0.014 0.006 2.178 0.029

Effects from NE to CM5

Sum of indirect 0.463 0.097 4.765 0.000

Specific indirect

CM5

CM4

NE 0.405 0.093 4.375 0.000

CM5

ADHD4

NE 0.057 0.026 2.194 0.028

STANDARDIZED TOTAL, TOTAL INDIRECT, SPECIFIC INDIRECT, AND DIRECT EFFECTS

STDYX Standardization

Two-Tailed

Estimate S.E. Est./S.E. P-Value

Effects from NE to ADHD5

Sum of indirect 0.064 0.010 6.404 0.000

Specific indirect

ADHD5

ADHD4

NE 0.060 0.010 6.185 0.000

ADHD5

CM4

NE 0.004 0.002 2.168 0.030

Effects from NE to CM5

Sum of indirect 0.054 0.011 4.800 0.000

Specific indirect

CM5

CM4

NE 0.047 0.011 4.400 0.000

CM5

ADHD4

NE 0.007 0.003 2.200 0.028

STDY Standardization

Two-Tailed

Estimate S.E. Est./S.E. P-Value

Effects from NE to ADHD5

Sum of indirect 0.061 0.010 6.419 0.000

Specific indirect

ADHD5

ADHD4

NE 0.057 0.009 6.199 0.000

ADHD5

CM4

NE 0.004 0.002 2.169 0.030

Effects from NE to CM5

Sum of indirect 0.051 0.011 4.806 0.000

Specific indirect

CM5

CM4

NE 0.045 0.010 4.405 0.000

CM5

ADHD4

NE 0.006 0.003 2.200 0.028

STD Standardization

Two-Tailed

Estimate S.E. Est./S.E. P-Value

Effects from NE to ADHD5

Sum of indirect 0.198 0.031 6.382 0.000

Specific indirect

ADHD5

ADHD4

NE 0.185 0.030 6.148 0.000

ADHD5

CM4

NE 0.014 0.006 2.178 0.029

Effects from NE to CM5

Sum of indirect 0.463 0.097 4.765 0.000

Specific indirect

CM5

CM4

NE 0.405 0.093 4.375 0.000

CM5

ADHD4

NE 0.057 0.026 2.194 0.028

MODEL MODIFICATION INDICES

NOTE: Modification indices for direct effects of observed dependent variables

regressed on covariates may not be included. To include these, request

MODINDICES (ALL).

Minimum M.I. value for printing the modification index 10.000

M.I. E.P.C. Std E.P.C. StdYX E.P.C.

WITH Statements

MDEP4 WITH CM4 10.005 -0.703 -0.703 -0.246

Beginning Time: 18:05:38

Ending Time: 18:05:39

Elapsed Time: 00:00:01

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