The Neurocognitive Profiles of Children Adopted from Care and their Emotional and Behavioral Problems at Home and School

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Abstract

Adoptees' mental health problems in childhood and later life are well described, but little attention has been paid to domestically adopted children's emotional and behavioral problems and neurocognitive profiles. The aim of this study was to describe the neurocognitive profiles of domestically adopted children in the UK and their parent- and teacher-rated emotional and behavioral problems. Forty-five children (*M* age = 75.96 months, *SD* = 12.98; 51.1% female) who were placed for adoption from public care at a *M* age of 22.14 months (*SD* = 14.21) completed a battery of age standardized neurocognitive tests, and adoptive parents and school teachers rated their emotional and behavioral problems. Children had more emotional and behavioral problems than the general population and over a fifth scored low (> 1 *SD* below the expected range for their age) in 5/6 neurocognitive tasks. Children who scored low on the non-verbal reasoning task were more likely to have more parent- and teacher-rated behavioral problems, and children's performance on the inhibitory control and cognitive flexibility tasks were associated with parent-rated behavioral problems. Children's verbal reasoning scores were positively associated with both parent- and teacher-rated emotional problems. Children who were adopted later in childhood scored significantly lower in non-verbal reasoning. Although longitudinal studies are needed to clarify the nature of neurocognitive functioning as a marker for later mental health problems, our findings underscore the importance of using comprehensive assessments to better recognize adopted children's difficulties and inform appropriate intervention initiatives.

Keywords: Adoption; childhood; mental health; neurocognitive profile.

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Early life adversity can have profound and long-term consequences for neurodevelopment [1]. There is considerable evidence that exposure to early life stress, such as neglect and maltreatment, can result in alterations to pertinent neurobiological systems associated with cognitive dysfunction and an increased vulnerability to mental health problems [2-6] Most children adopted from the public care system in the UK are removed from their birth family following experiences of abuse or neglect [7]. As an intervention, adoption drastically alters a child's circumstances in a way which may compensate for adversity experienced in early life. However, adoptees remain more likely to experience emotional and behavioral problems that endure into later life [8-10]. Adopted children are also overrepresented within clinical settings [11] and lag behind their classmates academically [12,13].

Adoptees' enduring emotional and behavioral problems and academic difficulties in the years post-placement may be related to delays in domains of neurodevelopmental functioning associated with early neglect, maltreatment, and/or disruptions to caregiving relationships. Evidence from post-institutionalized children demonstrates the effect of privation (e.g., lack of social stimulation, toys, opportunity to locomotor, malnutrition) on cognitive development. Generally, post-institutionalized children have decreased intellectual performance, language difficulties, and exhibit problems with executive functioning, including memory, learning, attention regulation, and inhibitory and emotional control [14, 15]; these difficulties have been attributed to differential organisation of white matter in the prefrontal cortex [16-18] and stress reactivity [19]. Although many post-institutionalized children show remarkable 'catch-up' in cognitive development following adoption [13, 20, 21], a number go on to experience emerging problems adolescence and young adulthood; or, 'sleeper effects', where problems may go undetected in early and middle childhood [22-24].

Inferences cannot, however, be made about domestic adoptees' neuropsychological profiles from studies of non-adopted children or children adopted under drastically different circumstances (e.g., post-institutionalized children [25]). In addition to potential genetic risk for psychiatric problems [26], domestically-adopted children may have experienced exposure to stress and/or toxic substances *in utero* and early adverse experiences that occur during crucial stages in development, such as neglect (though often not as extreme as post-institutionalized children), abuse, and household dysfunction [9, 27, 28]. By virtue of spending a longer time with their birth parents and in care, children who are older at the time of placement with their permanent family are more likely to have accumulated multiple pre-placement risk factors [9, 29]. Following removal from their birth family, all children contend with the loss of their primary caregiver, and possibly other family members, friends, community, and possessions. They may also spend a protracted period in care that is sometimes characterized by multiple moves between foster carers [29].

Most adopted children in the UK (in which 95% are domestic adoptions) are taken into local authority care due to maltreatment within the birth family [7]. Early experiences of neglect (failure to supervise one's child;[30]) and maltreatment (e.g., physical, sexual, emotional abuse) can result in alterations to structure and function of stress-sensitive regions of the developing brain (see [31, 32]. Although such alterations (e.g., hypervigilance or under arousal to stress or threat reactivity) may be considered adaptive within the context of a prevailing negative and frightening environment [33, 34], adaptations or 'recalibrations' can affect domains of neurodevelopment [2, 3] and consequently, a child's ability to thrive within, for example, the social and academic challenges of school [35, 36]. As such, domestically adopted children may have very different profiles of neurodevelopmental strengths and weaknesses to post-institutionalized and non-adopted children [25, 37].

Although evidence suggests that UK adopted children have elevated rates of emotional and behavioral problems post-placement [10, 37], the neuropsychological profiles of domestically adopted children that may underpin these difficulties have received scant attention [37, 38]. In some exceptions, domestic adoptees with histories of neglect and of placement instability have shown deficits in inhibitory control [39, 40] although not to the same severity as post-institutionalized children [41]. More recently, Wretham and Woolgar [37] profiled the executive functioning and emotional and behavioral problems of 30 primary school-aged UK adoptees (aged 7 – 11). Although parents reported elevated executive functioning (in the Behavior Rating Inventory of Executive Functioning), children scored lower on two of three practical executive functioning tasks (CANTAB Intra-Extra Dimensional Shift and Spatial Working Memory) compared to general population scores. By taking this approach, the authors identified specific problematic domains of executive functioning for adopted children, offering insight into possible avenues for tailored interventions. Yet given that early detection and intervention of children's difficulties is known to better offset risk trajectories before disorder emerges [3, 42], an examination of adoptees' neuropsychological profiles across a range of domains and their emotional and behavioral problems earlier in childhood is warranted.

The Present Study

Many children adopted from care in the UK have enduring mental health problems and may be less able to fulfil their potential academically [9, 10, 12] but little is known about their neurocognitive profiles [37]. To address the gap in the literature regarding domestically adopted children's neurocognitive functioning, we aimed to profile areas of neurocognition in a sample of children adopted from the UK public care system. To extend a limited body of work in older children (e.g., [37]) we investigated 4-to 8-year-old children's emotional and behavioral problems at home and school with the use of multiple informants (parents and teachers), and children completed a range of neurocognitive tasks.

Our specific aims were: (1) to profile children's emotional and behavioral problems at home and school and their performance on a range of neurocognitive tasks (verbal and nonverbal reasoning, receptive vocabulary, inhibitory control, cognitive flexibility, and episodic memory) in comparison to general population scores; (2) to investigate associations between children's performance on neurocognitive tasks and their emotional and behavioral problems; (3) to investigate associations between age at placement, emotional and behavioral problems and their performance on the neurocognitive tasks. We hypothesized that adoptees would have elevated emotional and behavioral problems and, in line with previous research, would show delays in both global measures of intellectual ability and in specific domains of neurocognitive functioning. Additionally, given the clustering of pre-adoptive risk factors associated with later age at placement, we hypothesized that being older at the time of adoptive placement would be associated with greater emotional and behavioral problems, and lower performance on neurocognitive tasks.

Method

Design

The study included 45 children aged 4 to 8 years who were adopted from local authority care in the UK and assessed at the Neurodevelopment Assessment Unit (NDAU) (https://www.cardiff.ac.uk/research/explore/research-units/neurodevelopment-assessment-unit). The NDAU provides the setting for a feasibility study of an innovative and rigorous approach to the assessment and characterization of neurodevelopmental problems in children. Thirteen adopted children (28.9%) were referred to the NDAU by their school teacher for a range of socioemotional, behavioral, and cognitive difficulties. Thirty-two (71.1%) children were also invited to attend an assessment via their own or their sibling's participation in the Wales Adoption Cohort Study; a prospective longitudinal study of 96 children placed for adoption from care in Wales between 01 July 2014 and 31 July 2015 (see [10] for more details of study; see [10, 28] for background of adoption in the UK; see Figure 1 for progression to sample). The school teachers of these children provided equivalent referral documents.

Ethical Considerations

Ethical permission was granted by Research Ethics Committees at Cardiff University (School of Psychology) Research Ethics Committee and the study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from a parent or caregiver for each child who participated in the assessment.

Participants

Of the 45 children assessed in the present study, 23 (51.1%) were female, and were a mean age of 75.96 months, *SD* = 12.98, range 56 to 99 months. Children were placed for adoption at a mean age of 22.14 months (*SD* = 14.21, range 5 to 60 months). The adoptive parents in the study had a mean age of 38.80 (*SD* = 5.94) years at the time of adoption, and the majority (97.8%) were white British. Most parents were in a relationship (95.6%). At the time of the assessment, most parents were in full- or part-time work (81.8%), 42.2% had postgraduate degrees, and 27.3% earned more than £60,000 a year which was higher than the UK average according to Office for National Statistics data [43].

Characterization of Pre-Adoptive Adversity in the Sample

Table 1 summarizes the children's pre-adoptive histories, including number of days spent with birth parents, number of days spent in local authority care, children adopted as part of a sibling group, and number of adverse childhood experiences (ACEs). For the 32/45 children who participated in the neurodevelopmental assessment as part of their participation in the Wales Adoption Cohort Study, pre-adoptive adverse experiences were retrieved from social worker records. Adoptive parents of 3/13 NDAU-referred children also reported on their child's experiences of pre-adoptive adversity. These experiences were coded for presence or absence of 10 categories of ACEs (see [9, 44]) and included abuse (emotional, physical, or sexual), neglect, and household dysfunction (domestic violence, parental separation, substance abuse, alcohol abuse, mental illness, or incarceration).

[Insert Table 1 here]

Sample Representativeness

To investigate the representativeness of the sample, we compared the $N = 45$ families who participated in the present study to the 65 families taking part in the Wales Adoption Cohort Study who were eligible for inclusion (aged between 4-7 at the time of recruitment for an assessment at the NDAU; see Figure 1). We detected no differences in parent characteristics (age at adoption, relationship status, ethnicity, income, employment, or education) or child characteristics (gender, age at adoptive placement), all *p*s > .05. We also examined the sample's representativeness of the population of interest, by comparing the sample to all children adopted between 2013 and 2014 ($N = 374$) in a review of social work records. The sample was representative in terms of gender distribution, although the children in the present study were younger at the time of adoption ($M = 1.39$, $SD = 1.33$ in the present sample versus $M = 2.05$, $SD = 1.95$ in the population of interest $p = .004$).

Procedure

The children and an adoptive parent (86.7% mothers) were invited to the NDAU for two assessment sessions; the first for 3 hrs, the second for 2 hrs. Following a short introduction together, child completed assessments in the testing room with a trained developmental assessor. Assessments included a battery of well-established tasks used internationally in research and clinical practice targeting underlying dimensions of functioning, based on the Research Domain Criteria (RDoC) approach; a research framework to investigate mental disorders by measuring domains of functioning (emotion, cognition, motivation, and social behavior) (https://www.nimh.nih.gov/research/research-funded-by-nimh/rdoc/index.shtml). At the same time, the child's parent completed an interview and questionnaires in a separate interviewing room.

Measures

Age at adoptive placement. For children recruited for a neurodevelopmental assessment from the Wales Adoption Cohort Study sample, information pertaining the age at which the child was moved into their permanent placement was gathered from social work records (child adoption record). For children who were referred to the NDAU by their teacher, parents reported the age at which the child was moved into their permanent placement (came to live with them).

Emotional and behavioral problems. Adoptive parents and teachers completed the Strengths and Difficulties Questionnaire (SDQ) [45]. For comparison with the general population, we profiled children based on their emotional, peer, conduct, and hyperactivity problem subscales, and prosocial behavior subscale. A higher score is indicative of more problems for all subscales (where children could score a maximum of 10 for each scale), except for the prosocial scale, where higher scores correspond to strengths in prosocial behavior. All subscales had acceptable to good levels of internal consistency for parent and teacher reports (αs ranged from .74 to .82 and from .57 to .87 respectively). Children's total emotional problems (sum of emotional and peer; *internalizing*) and behavioral (sum of conduct and hyperactivity, *externalizing*) scores were used to investigate relationships with neurocognitive performance.

Neurocognitive tasks.

Verbal reasoning. Verbal reasoning tasks were selected from the Lucid Ability Computerised Assessment System for children aged 4 to 16 years, which has demonstrated good test-retest reliability, internal consistency, and validity [46]. Four to six-year-olds were administered the 'Picture Vocabulary Test', in which five pictures appeared a computer screen and the child was asked "Which picture goes best with the word [e.g., emergency]?" The child was asked to point to or click on their chosen picture using a mouse. Before the test phase, children were given two interactive practice items where feedback was provided; no feedback was provided for test items. Children over 7 years of age were given the ‘Link Word’ task, where children were shown two conceptually linked pictures on the screen, with a choice of 6 potential ‘link words’ in between. The child’s task was to select the word that ‘best’ linked the two pictures together. The child could click on all the words to hear the computer speak each word before making their choice. The test items were preceded by two practice items where audio feedback was given; test items were administered with no feedback. Both tests terminated when the child’s ability had been exceeded.

Non-verbal reasoning. Non-verbal reasoning tasks were also selected from the computer-based Lucid Ability assessments [46]. Children between 4 and 6 years of age were presented with ‘Dressing Up’; a mental rotation task, in which the child is presented with a character called ‘Zoid’ wearing different accessories (e.g., boots, gloves, umbrella) in the middle of the screen. The child is presented with four of Zoid’s ‘friends’ who may be wearing different accessories or at different rotated orientations, and the child is asked to find the friend who is copying Zoid exactly by clicking on their chosen character. Rotations may be horizontal (e.g., upside-down), vertical (e.g., back to front), or, both. Rotations and accessories are ordered in increasing difficulty. Each child was given four interactive practice trials, where the computer provided standard feedback, “No, this friend has his boot on the other foot! Try again.” After an interactive practice phase with audio feedback, children completed 22 identical trials with no feedback. Children over the age of 7 were given an equivalent ‘Matrix Problems’ task, they were shown a matrix of abstract puzzles on a 3x3 matrix with one ‘piece’ of the matrix missing that could be filled by understanding of the pattern of the puzzle. Children selected the missing ‘piece’ out of a choice of 6 pieces. After an interactive practice phase with audio feedback, they were given a series of puzzles with no feedback out of a pool of 57 puzzles. The test terminated when the child’s ability was exceeded.

Receptive language. Children's receptive vocabulary was assessed using the *British Picture Vocabulary Scale* (BPVS) [47]. In each trial of the test, children were presented with four pictures. The experimenter said one word aloud, and child was asked to select the picture that matched with the meaning of the word. Children received two practice trials where feedback was given if incorrect. The task was terminated after children exceeded a predefined threshold of errors.

Inhibitory control. Children were administered the 'Flanker' Inhibitory Control and Attention Test from the NIH Toolbox [48]. In this test, children were required to match to a target stimulus while inhibiting attention to its flanking stimuli (fish for children aged 4-7 years, arrows for 8-year-olds) presented on a computer tablet. In some trials, the target stimuli pointed in the same direction as the flanking stimuli (congruent trials), and in others the target stimuli pointed in the opposite direction (incongruent trials). Task instructions were given verbally by the experimenter with accompanying practice trials. Children between 4 and 7 were then presented with 20 fish test trials; if they scored ≥ 90% they were given 20 additional trials with arrow targets. Eight-year-olds were presented with 20 arrow trials only. Children's standardized scores were based on a 2-vector scoring method that uses accuracy and reaction time in the computed score calculation.

Cognitive flexibility. The 'Dimensional Change Card Sort Test' (DCCS) from the NIH Toolbox [48] was used to measure cognitive flexibility. Children were required to match bivalent test pictures (e.g., blue trucks, yellow balls) to target pictures on a computer tablet. Children were directed to the dimension via audio specifying "colour" or "shape". Children were presented with switch trials where, for example, after matching by shape over multiple trials, they would then be told to match by colour for 1 trial, and then back to shape in the following trial. Like the Flanker test, standardized scores were based on a 2-vector scoring method that uses accuracy and reaction time in the computed score calculation.

Episodic memory. The Picture Sequence Memory Test (PSMT) from the NIH Toolbox [48] was selected to assess episodic memory. Children were presented with a series of pictures on a computer tablet (from 6-18 pictures depending on age) depicting activities accompanied by audio descriptions (e.g., "Fly a kite" or "Play in the sand"). After each series of pictures, children were presented with all pictures from the sequence, and were asked to drag and drop the images into the correct order. Children's scores were based on the number of adjacent pairs placed correctly over two trials.

Data Analysis

Our first aim was to profile children's emotional and behavioral problems at home and school and children's performance on neurocognitive tasks. We described children's scores on the problem scales (emotional, peer, conduct, and hyperactivity problem subscales, and prosocial behavior) using the four-band classification of scores as either 'close to average' (representing 80% of the population) 'slightly raised' (10%), 'high' (5%), and 'very high' (5%). To compare adopted children's scores on the problem scales to general population scores, we used independent samples *t*-tests to identify significant group mean differences. To profile children's performance on the neurocognitive tasks, we used age-corrected standard scores, for which the normative mean is 100 and standard deviation is 15. A score of 85 to 114 indicated that a child's performance is within 1 *SD* above or below the national average compared with like-aged participants; approximately two-thirds of the population will have scores that fall in this range. Our second aim was to investigate associations between children's performance on neurocognitive tasks and their total parent- and teacher-rated emotional (internalizing) and behavioral (externalizing) problems, and thirdly, to investigate associations between age at placement, total parent- and teacher-rated emotional and behavioral problems and their performance on the neurocognitive tasks. To test associations between variables of interest, we used Pearson or Spearman correlations according to the distribution of the data, and followed up with hierarchical regression models where $p < .05$. Associations between performance on neurocognitive tasks and children's total emotional and behavioral problems were tested to see if they held whilst controlling for identified covariates and global ability (non-verbal reasoning). We conducted preliminary analyses to ensure that, for all regression models, there were no violations of assumptions of linearity, multicollinearity, homoscedasticity, and that residuals were normally distributed.

Results

Adoptees' Emotional and Behavioral Problems

Descriptive statistics for parent and teacher reports of children's SDQ problem subscale scores are shown in Table 1 along with normative data based on a large representative sample of British children between the ages of 5 and 10 (see [49]). Children were rated as having more problems on all subscales (and fewer prosocial behaviors) on the SDQ by parents and teachers in comparison to general population scores (all *p*s < .01). Table 2 also shows the categories of children's problem subscale scores. According to parents and teachers, a notably high percentage of children scored in the high to very high groups, confirming the high-risk nature of the sample.

[Insert Table 2 here]

There was moderate to high level of agreement between parents and teachers in their ratings of children's SDQ subscale scores (emotional $r_s(45) = .34$; conduct $r_s(45) = .70$; hyperactivity $r_s(45) = .64$; peer $r_s(45) = .51$; prosocial behavior $r_s(45) = .71$). Children who were referred to the NDAU by their teacher ($n = 13$) were reported to have significantly more conduct and peer problems and display less prosocial behavior than those who were invited for assessment via their participation in the Wales Adoption Cohort Study (all *p*s < .05). Parents of children referred to the NDAU also reported their children to have more problems on all subscales except for peer problems (*p*s < .05). As such, recruitment strategy (NDAU referral or invitation) was included as a covariate in all regression analyses. No sex differences were detected in children's problem scales reported by parents and teachers.

Adoptees' Neurocognitive Profiles

Descriptive statistics for children's performance on the neurocognitive tasks are presented in Table 3. Although children's standardized scores fell in the average range for all tasks, a notable percentage of children scored > 1 *SD* below the expected range. Over 20% of children scored low on episodic memory task (n = 9, 21.4%); over a quarter scored low on the receptive vocabulary (n = 11, 26.2%) and cognitive flexibility (n = 11, 26.8%) tasks; and over a third scored low on the inhibitory control (n = 16, 39.0%) and non-verbal reasoning (n = 17, 41.5%) tasks. No differences were detected in children's performance on the neurocognitive tasks according to recruitment method or gender (*p*s > .05).

[Insert Table 3 here]

Associations between Children's Neurocognitive Performance, Emotional and Behavioral Problems, and Age at Placement

Table 4 shows associations between children's parent- and teacher-rated total emotional (sum of emotional and peer scales) and behavioral (sum of conduct and hyperactivity scales) problems and their performance on the neurocognitive tasks, with recruitment status partialled out. Children's performance on the verbal reasoning task was positively associated with both parent and teacher reported total emotional problems. Lower non-verbal reasoning scores were associated with more behavioral problems according to both parent and teacher reports. Children's performance on the inhibitory control and cognitive flexibility tasks were negatively associated with their parent reports of behavioral problems (all *p*s < .05). Although the effect size of the relationship between inhibitory control and teacher-rated behavioral problems was not negligible, this relationship did not reach significance (p = .10).

[Insert Table 4 here]

We investigated these relationships further using regression; in each model, recruitment status and non-verbal reasoning were entered into the first and second steps, respectively. First, we describe analyses regarding children's emotional problems at home and school: in the first model, verbal reasoning was entered into the third step; together, all variables contributed significantly to parent ratings of children's emotional problems (R^2 = .33, $F(3, 37) = 6.00$, $p < .01$), where verbal reasoning performance represented a significant step in the model, R^2 change = .11, $p < .05$; higher verbal reasoning scores were associated with more parent-rated emotional problems (see Model 1 in Table 5). Similarly, in a second model predicting teacher-rated emotional problems, where verbal reasoning was again entered at the third step, the variables contributed significantly to teacher-rated children's emotional problems (R^2 = .23, $F(3, 37) = 3.67$, $p < .05$). Verbal reasoning performance again, represented a significant step in the model, R^2 change = .10, $p < .05$; higher verbal reasoning scores were associated with more emotional problems according to teachers (see Model 2 in Table 5).

[Insert Table 5 here]

Secondly, we followed up significant associations between children's neurocognitive performance and parent- and teacher-ratings of child total behavioral problems. With recruitment status and non-verbal reasoning entered into the first and second steps of the first model, and the addition of inhibitory control in the third step, the variables contributed significantly to parent-ratings of behavioral problems (R^2 = .46, $F(3, 36) = 10.21$, $p < .001$). Non-verbal reasoning represented a significant step in the model R^2 change = .11. Inhibitory control also represented a significant third step, R^2 change = .06 (both ps < .05). Lower non-verbal reasoning and inhibitory control scores were associated more parent-rated behavioral problems (both ps < .05, see Model 3 in Table 5). Another model, where cognitive flexibility was entered at the third step, was overall, significant (R^2 = .42, $F(3, 36) = 10.47$, $p < .001$), with cognitive flexibility representing a significant step R^2 change = .07, $p < .05$). In this model, just lower cognitive flexibility scores were associated with more parent-rated behavioral problems (see Model 4 in Table 5).

We did not detect significant associations between child age at placement and their parent- and teacher-rated emotional and behavioral problems (both *p*s > .05). Children who were older at the time of adoption did, however, have lower non-verbal reasoning scores r_s (40) = -.37, $p < .05$. Although it did not reach significance, it is noteworthy that the relationship between age at placement and cognitive flexibility approached significance r_s (40) = -.29, $p = .07$.

Discussion

Most domestically adopted children have early experiences of neglect, maltreatment, and/or family disruption [7, 9], and are more likely to have emotional and behavioral problems and lower academic attainment across childhood, adolescence, and emerging adulthood compared to their non-adopted counterparts [8, 12]. We profiled emotional and behavioral problems and performance on neurocognitive tasks in a sample of 4-to-8-year old children who were adopted from local authority care in the UK.

In line with our hypothesis, parents and teachers reported that the children had elevated emotional and behavioral problems compared to general population scores. This finding aligns with similar comparisons of older children [37] and with the numerous studies that demonstrate domestic adoptees and looked after children have more adjustment problems than their non-adopted counterparts [12, 50]. Yet interestingly, and contrary to our hypothesis, on average the children performed within the expected range across all neurocognitive abilities examined. Our findings may represent a gap between children’s neurocognitive competence and emotional and behavioral adjustment, or an *adoption décalage*, previously indicated by discrepancies between adopted children’s positive attainment in terms of IQ and their delayed attainment at school [13]. It is speculated that the adoption décalage may be intensified by children’s difficulties in managing the social and emotional demands in particular settings (e.g., navigating group interactions at home and school) that impact functioning, in contrast to the nature of one-on-one assessments such as those conducted in the present study. However, given that other studies of older domestic adoptees have shown lower functioning in specific domains of cognitive development [37], it is quite possible sleeper effects of early adversity on neurocognitive performance emerge later in development (i.e., [51]).

Although most children performed within the average range on the neurocognitive tasks, a notable percentage scored below the expected range on most tasks, particularly inhibitory control and non-verbal reasoning, where approximately 40% of children scored below the expected range for their age. Indeed, children who scored below the expected range on the non-verbal reasoning task were more likely to show more parent- and teacher-rated behavioral problems. Children who older at the time of their adoptive placement also had lower non-verbal reasoning scores, indicating that this may be a particular area of need for children who may have experienced a greater accumulation of pre-placement risk factors, such as early adverse experiences and multiple moves in care [9, 29]. Our findings align with other studies that show lower IQ in children who experience pre- and post-natal adversity [30, 52-54] and are likely explained by both genetic and environmental factors, although these cannot be disentangled within the present study. Cognitive functioning is highly heritable [55] and early life stress can harm brain development—particularly during periods of rapid neuronal growth and neuroplasticity— that can affect both cognitive functioning and behavioral problems [56].

Although as a sample, children performed within the normal range in the neurocognitive tasks, we detected significant negative associations between domestic adoptees' inhibitory control and cognitive flexibility and parent ratings of behavioral problems. Our findings corroborate a number of studies showing that domains of effortful control have implications for the development of behavioral problems across development [57-59]. Given that self-regulation tasks that comprise a 'hot' or emotional component may be a better predictor of behavioral problems in childhood than more abstract, 'cool' effortful control tasks, such as those used in the present study [60] it is quite possible these findings represent children's ability to regulate (particularly, negative) emotions, and thus requires further study to probe additional domains of this construct.

These findings underscore the importance of using personalized, comprehensive assessments (e.g., [61]) to best address the complex individual differences in adoptees' neurodevelopmental profiles [34]. From this perspective, it is vital to consider the heterogeneity of adoptees' early experiences and the consequences these have for diversity of presentation and needs at an individual level [34, 38]. These areas of need or signs of difficulty may not be adequately recognized or addressed within diagnosis-led approaches, particularly when children may have functional impairments not captured by diagnosis, or have elevated, but subthreshold presentations of emotional and behavioral problems, that place them at risk of disorder later in development [38, 62]. A finer-grained, systematic approach to assessment may better inform parents and front-line professionals of targets for intervention that are tailored to each child's area(s) of need.

Contrary to our hypothesis, children with higher verbal reasoning scores were reported to have more emotional problems by both their parents and school teachers. Although unexpected, early evidence suggests that verbal ability can be associated with higher levels of depression and lower self-esteem in adolescence [63]. Given that it is well-established that verbal processing is positively associated with social cognitive ability (e.g., [64]) we suggest this relationship may be mediated by children's ability to understand and interpret the emotions and minds of others. A sophisticated understanding of mental states is largely considered an advantage; for example, social-cognitively competent children have more positive interactions among peers and tend to do well academically [65]. However, evidence suggests that a mature understanding of minds exacerbates the relationship between peer rejection and neglect and emotional problems [66]. It is quite possible that adopted children with high verbal and social cognitive abilities may be more sensitive to challenging social situations and react with distress; this speculation warrants further study.

Limitations

Although the findings in our study have strength in the use of multiple informants of child adjustment and of task-based neuropsychological assessments, as with other examinations of adoptees' cognitive functioning and behavior [40], the cross-sectional nature of the study precludes any conclusions about direction of causality. Ideally, neurocognitive assessments conducted pre- and post-adoptive placement in a larger sample of adoptees would provide an indication of patterns of continuity and change over the course of a child's transition to their adoptive placement and in later childhood and adolescence. However, such a study would have to overcome significant practical challenges in recruitment and follow-up of children from public care through to their adoptive placement.

We closely examined the representativeness of the present sample in line with all children adopted in Wales in a 13-month period, and alongside all the families taking part in the Wales Adoption Cohort Study whose child was eligible for an assessment. Consistent with the restriction of range that is common of adoptive families [67], the participants in the study, though largely representative of the population of interest, were generally of high socioeconomic status. This may have affected our comparison of adoptees' parent- and teacher-rated emotional and behavioral problems with scores from the general population. Further, the time commitment associated with the extensive battery of assessments inevitably resulted in a trade-off with sample size which is likely to have affected our analyses in terms of power. For example, although non-significant, the effect sizes for the associations detected between children's inhibitory control and behavioral problems and between age at placement and cognitive flexibility were not negligible. However, it is reassuring that many findings were consistent across parent- and teacher-reports of child emotional and behavioral problems.

Given that the focus of the NDAU is to assess the feasibility of an innovative approach to the assessment of young children with a range of support needs rather than a study specifically of adoption, we were unable to collect full pre-adoptive histories for the NDAU-referred children. As such, consistent with other studies, we used age at adoption as a proxy of children's experiences of pre-placement adversity, for example [68]. However, this approach has been criticised because, implicit in the use of age at adoption is the assumption of a linear relationship between time with birth parents and in care and the magnitude of pre-placement adversity [10, 69]. This indicator, therefore, does not necessarily account for the complexities of children's histories that affect timing of removal, for example, the duration or severity of children's experiences of abuse and/or neglect, or substance exposure *in utero*. As such, future studies would do well to investigate adopted children's neuropsychological strengths and difficulties within the context of their complex and individual early experiences.

Conclusion

It is well known that adoptees are at risk of poor psychological and academic outcomes that can endure into later life. However, to our knowledge, this study is the first to profile 4-to-8-year old UK domestic adoptees' neurocognitive abilities in addition to their emotional and behavioral problems. Both parents and teachers indicated that adopted children had elevated emotional and behavioral problems, and although on average, children performed in the average range on the neurocognitive assessments, areas of difficulty were noted for a relatively high proportion of children. This study underscores the importance of the assessment of adoptees across multiple domains of development to better facilitate recognition of areas of strength and difficulty. With this methodology brings the potential of an individualised approach to targeting domains for early intervention and prevention before psychiatric and academic problems emerge.

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Table 1

Characterization of pre-adoptive experiences of children in the sample

Number of days spent with birth parents (*M*, *SD*)	263.73	364.96
Number of days spent in care (*M*, *SD*)	416.40	173.32
Adopted in a sibling group (*n, %*)	12	30.8
Count of pre-adoptive adverse experiences (*n, %*)*		
None	16	45.7
2	6	17.1
3	5	14.3
4 +	8	22.9

Note. *Based on data available for 35/45 children in the present study for whom social work records/maternal reports were available.

Table 2.

SDQ parent and teacher data for adoption sample and general population scores

	Adoption sample (*N* = 45)					**Population sample (*N* = 5855)**
	n (%) low to average	*n* (%) slightly raised	*n* (%) high	*n* (%) very high	*M* (*SD*)	*M* (*SD*)
Parent report						
Emotional	24 (53.3)	5 (11.1)	7 (15.6)	9 (20.0)	3.73 (2.82)	1.9 (2.0)
Conduct	17 (37.8)	5 (11.1)	13 (28.9)	10 (22.2)	3.80 (2.64)	1.6 (1.7)
Hyperactivity	18 (40.0)	12 (26.7)	3 (6.7)	12 (26.7)	5.93 (3.12)	3.6 (2.7)
Peer	26 (57.8)	4 (8.9)	6 (13.3)	9 (20.0)	2.38 (2.35)	1.4 (1.7)
Prosocial*	23 (51.1)	6 (13.3)	7 (15.6)	9 (20.0)	7.33 (2.33)	8.6 (1.6)
Total problems**	20 (44.4)	5 (11.1)	4 (8.9)	16 (35.6)	15.84 (7.79)	8.6 (5.7)
Teacher report						**Population sample (*N* = 4801)**
Emotional	31 (68.9)	2 (4.4)	5 (11.1)	7 (15.6)	2.71 (2.46)	1.5 (1.9)
Conduct	28 (62.2)	5 (11.1)	4 (8.9)	8 (17.8)	2.42 (2.53)	0.9 (1.6)
Hyperactivity	21 (46.7)	5 (11.1)	8 (17.8)	11 (24.4)	5.60 (3.42)	3.0 (2.8)
Peer	27 (60.0)	12 (26.7)	4 (8.9)	2 (4.4)	2.22 (1.86)	1.4 (1.8)
Prosocial*	30 (66.7)	5 (11.1)	1 (2.2)	9 (20.0)	6.42 (2.93)	7.3 (2.4)
Total problems**	22 (48.9)	9 (20.0)	4 (8.9)	10 (22.2)	12.96 (7.15)	6.7 (5.9)

Note. Population data is based on a large representative sample of British children between the ages of 5 and 10 (see Meltzer, Gatward, Goodman, & Ford, 2000). *For prosocial behavior means and SDs, higher scores /10 represent more prosocial behaviors. The low to average, slightly raised, and high to very high groups represent children with prosocial problems. **Total problems represent sum of emotional, conduct, hyperactivity, and peer subscales.

Table 3.

Children's performance on neurocognitive tasks

	n***	***n* (%) with score < 85 (low)**	***n* (%) with score 85-114 (average)**	***n* (%) with score > 114 (high)**	**Range**	**Mean**	***SD***
Receptive language (BPVS)	42	11 (26.2)	30 (71.4)	1 (2.4)	63 to 131	90.71	12.24
Verbal reasoning (Picture Vocabulary Test/Link Words)	44	3 (6.8)	31 (70.5)	10 (22.7)	64 to 125	103.05	12.92
Non-verbal reasoning (Dressing Up/Matrix Problems)	41	17 (41.5)	20 (48.8)	4 (9.8)	60 to 129	89.44	17.04
Inhibitory control (Flanker)	41	16 (39.0)	25 (61.0)	0 (0.0)	57 to 111	85.92	13.89
Cognitive flexibility (DCCS)	41	11 (26.8)	28 (68.3)	2 (4.9)	54 to 117	92.87	13.43
Episodic memory (PSMT)	42	9 (21.4)	25 (59.5)	8 (19.0)	69 to 146	96.90	13.19

Note. *n varies by task as some children refused to complete assessments.

Table 4.

Partial associations between children's emotional and behavioral problems and performance on neurocognitive tasks, controlling for recruitment status

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Parent-rated emotional problems	-	.20	$.50^{**}$	-.09	-.12	$.38^{*}$	.09	-.05	.10	-.12
2. Parent-rated behavioral problems		-	$.39^{*}$	$.76^{**}$	-.20	.17	$-.40^{*}$	$-.39^{*}$	$-.45^{**}$	-.24
3. Teacher-rated emotional problems			-	.22	-.05	$.35^{*}$	.03	-.10	-.19	-.12
4. Teacher-rated behavioral problems				-	-.19	.01	$-.42^{**}$	$-.27^{+}$	-.21	-.19
5. Receptive language					-	$.30^{+}$	-.09	$.30^{+}$	.03	.10
6. Verbal reasoning						-	.00	.16	$.41^{**}$	.17
7. Non-verbal reasoning							-	.25	$.40^{**}$	.01
8. Inhibitory control								-	$.29^{+}$	.07
9. Cognitive flexibility									-	.18
10. Episodic memory										-

Note. $df = 37$. $^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$. Coefficients between episodic memory and variables of interest were calculated using Spearman's rho partial correlations. Total emotional (sum of emotional and peer scales) and behavioral (sum of conduct and hyperactivity scales) problems are based on teacher reported problems in the SDQ.

Table 5.

Regression analyses testing effect of children's performance on neurocognitive tasks on parent- and teacher-rated total emotional and behavioral problems

	Model 1					Model 2			
	Parent-rated emotional problems					Teacher-rated emotional problems			
	R^2	β	B	95% *CI*		R^2	β	B	95% *CI*
	$.33^{*}$					$.23^{*}$			
Constant			-8.83	-20.43, 2.77	Constant			-8.05	-18.83, 2.73
Recruitment status		$.44^{**}$	4.07^{**}	1.46, 6.68	Recruitment status		$.31^{*}$	2.50^{*}	.08, 4.92
Non-verbal reasoning		.08	.02	-.05, .09	Non-verbal reasoning		.13	.03	-.04, .09
Verbal reasoning		$.33^{*}$	$.12^{*}$	.02, .21	Verbal reasoning		$.31^{*}$	$.10^{*}$	.01, .18
	Model 3					Model 4			
	Parent-rated behavior problems					Parent-rated behavior problems			
	R^2	β	B	95% *CI*		R^2	β	B	95% *CI*
	$.46^{*}$					$.47^{*}$			
Constant			23.20^{**}	13.89, 32.50	Constant			23.85^{**}	14.38, 33.33
Recruitment status		$.59^{**}$	6.99^{**}	4.01, 9.97	Recruitment status		$.63^{**}$	7.53^{**}	4.48, 10.58
Non-verbal reasoning		$-.27^{*}$	$-.09^{*}$	-.17, -.004	Non-verbal reasoning		-.22	-.07	-.15, .02
Inhibitory control		$-.26^{*}$	$-.10^{*}$	-.19, -.002	Cognitive flexibility		$-.30^{*}$	$-.11^{*}$	-.22, -.01

Note. $^{*}p < .05$, $^{**}p < .01$. $N = 40$ in Model 1, 40 in Model 2, 39 in Model 3, and 39 in Model 4. The coefficients presented in the table are those obtained in the final models. Adjusted $R^2 = .27$ for Model 1, .17 for Model 2, .42 for Model 3, and .42 for Model 4.

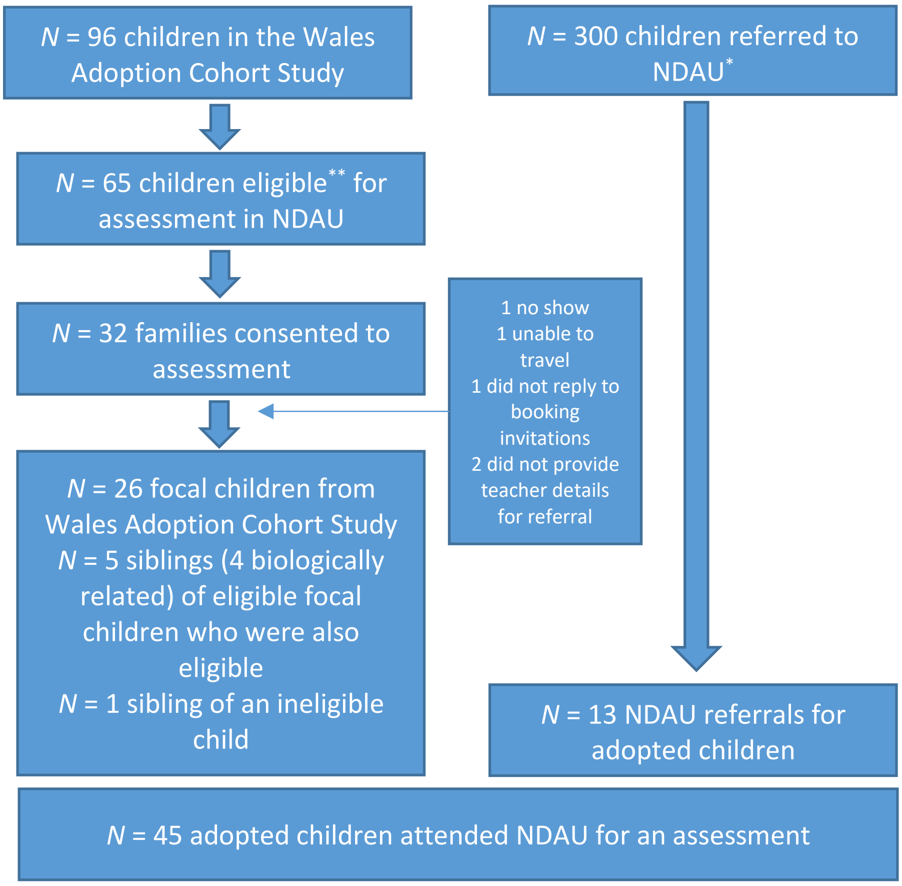

Figure 1. Progression to sample in the present study. *Data collection ongoing; **child between 4 and 7 years of age at time of recruitment for assessment.