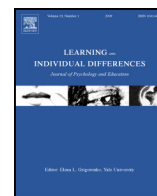




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A longitudinal study of the association between inattention, hyperactivity and impulsivity and children's academic attainment at age 11

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ABSTRACT

Background: The link between inattention and hyperactivity/impulsivity and poor academic outcomes is well established. Children with mild difficulties can go unnoticed yet may be at risk of poor academic outcomes.

Aims: To investigate the link between a continuum of inattention, hyperactivity and impulsivity at age five and academic attainment at age 11.

Sample: The sample comprised 46,369 children from 1812 English primary schools.

Methods: Reading and mathematics when starting school. Teachers rated behaviour at age five. English and mathematics were assessed at age 11.

Results: A substantive negative direct relationship was found between the severity of inattentive behaviour at age 5 and attainment at age 11. Hyperactivity was not significant but impulsivity was weakly but positively associated with attainment. These relationships applied across the whole range of behaviour scores.

Conclusions: Investigation of the continuum of symptoms has important implications for the teachers; particularly for those children with mild inattention whose difficulties may go unnoticed.

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1. Introduction

The association between academic attainment and inattentive, hyperactive and impulsive behaviour, which is characterized by Attention Deficit Hyperactivity Disorder (ADHD), has been documented in previously published studies (Brooke et al., 2009; Shaw et al., 2012). These studies have focused on clinical populations. Other large-scale longitudinal school-based studies have investigated the impact of severe ADHD-type behaviour on the academic attainment of children who do not necessarily have a formal diagnosis of the disorder (Polderman, Boomsma, Bartels, Verhulst, & Huizink, 2010; Washbrook, Propper, & Sayal, 2013; Sayal, Washbrook, & Propper, 2015). The findings from the school-based studies highlight the level of risk of underachievement for children with undiagnosed severe behavioural problems and have important implications for educational policy and practice. However, inattentive, hyperactive and impulsive behaviours present themselves on a continuum and large-scale longitudinal studies to date have not investigated the level of risk of negative academic outcomes for children across the continuum throughout primary education. Children with less severe ADHD symptoms, which would not qualify them for a formal diagnosis of ADHD and which may not cause significant issues for

teachers in the classroom may, nevertheless, be at risk of academic problems, and this needs to be further investigated. Thus the objective of this longitudinal study of a large school-based sample of children in England was to investigate the question: What is the strength of association between different severities of inattentive, hyperactive and impulsive behaviour in young children and their academic attainment at the end of primary school at age 11 years after taking baseline factors into account?

ADHD is characterized by inattentive, hyperactive and impulsive behaviours, and for a diagnosis to be made, a number of criteria must be met. The fourth version of the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association, 1994) identified three sub-types of ADHD; 'Combined' where an individual displays symptoms of inattention, hyperactivity and impulsivity, 'Predominantly Inattentive' and 'Predominantly Hyperactive/Impulsive'. The DSM-IV listed eighteen criteria which characterized ADHD. To qualify for a diagnosis of ADHD, a number of these criteria should be met at a persistent and severe level by an individual in a range of environments, with onset before the age of seven. This has been superseded by the fifth edition of the DSM (American Psychiatric Association, 2013) but the list of diagnostic criteria for ADHD is unchanged and the two domains of inattention and hyperactivity/impulsivity remain.

The prevalence of individuals diagnosed with ADHD varies, depending on factors such as age, the reliability of the diagnostic criteria and

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diagnostic practices. In the UK, the prevalence rate has been estimated to be 2.2% (Ford, Goodman, & Meltzer, 2003). Polanczyk, de Lima, Horta, Biederman, and Rohde (2007) conducted a systematic literature review which analysed 102 studies that had investigated the prevalence rate of ADHD in community or school-based samples of individuals who were 18 years or younger using either the diagnostic criteria for ADHD in the DSM versions III, III-R or IV (American Psychiatric Association, 1980, 1987 and 1994 respectively) or the diagnostic criteria for hyperkinetic disorder in the International Classification of Diseases (ICD, World Health Organization, 1993). The number of participants in these studies totalled 171,756. Their findings estimated a world-wide pooled prevalence rate of ADHD/Hyperkinetic Disorder of 5.3% although there is international variation, for example higher prevalence rates have been reported in the United States (Rowland et al., 2002).

Children who are diagnosed with ADHD have frequently been found to fall behind their peers, academically (for example, Barkley, Fischer, Edelbrock, et al., 1990) and school-based studies have shown that this trend extends beyond clinical samples to children with severe ADHD-type behaviour but without necessarily a formal diagnosis of the disorder. From their systematic review of sixteen studies, Polderman et al. (2010) concluded that children with attentional and hyperactivity problems are at risk of lower academic outcomes. Of the sixteen studies which they reviewed, ten were small-scale clinical samples and six were community population samples. A range of different measures of attentional difficulties and outcomes were used across the studies but no distinction was made between the ADHD sub-types in five of the studies. Washbrook et al. (2013) analysed data from a large cohort of children ($n = 11,640$) collected in the Avon Longitudinal Study of Parents and Children (ALSPAC). The authors linked parents' ratings of their children's level of hyperactivity/inattention at the age of 3 to the GCSE examination results at the end of compulsory education in England at age 16. They found that after adjusting for a broad range of confounder variables, including IQ at age 8, children with severe hyperactivity/inattention problems at age 3 attained significantly lower examination results at age 16 than their peers. For example, boys with high levels of hyperactivity/inattention at age 3 were 33% more likely to not achieve a Grade C (the lowest grade considered to be accepted by higher education and employers as passing the examination) in age 16 examinations. However, the authors recognized that one limitation of the study was the composition of the behaviour rating scale, Goodman's Strengths and Difficulties Questionnaire (SDQ), which did not allow for the association between academic attainment and the separate domains of inattention and hyperactivity to be investigated.

Negative outcomes extend beyond academic domains and although this study focuses on academic attainment, other outcomes are no less important. A systematic review of 351 longitudinal studies compared the long-term (which was defined as more than two years) outcomes of individuals with ADHD receiving treatment with those not receiving treatment. They found negative associations between ADHD and drug use/addictive behaviour, social functioning, self-esteem, occupation, driving and obesity (Shaw et al., 2012). Moyá et al. (2014) conducted a twenty-year follow-up study of a community-based sample of boys in London, England. From an initial sample of 3215 boys, 40 who were identified at age 6–7 years as having pervasive hyperactivity and 25 with no identified behavioural difficulties were followed up at age 27. Not all of those identified as having pervasive hyperactivity at age 6–7 were diagnosed with ADHD as adults but those who were ($n = 9$) reported difficulties with social relationships and negotiation skills. Those with milder hyperactivity did not report experiencing the same level of negative outcomes at follow-up.

Recent studies have identified differences in the strength of the link between inattention, hyperactivity and impulsivity, and academic attainment. Merrell and Tymms (2005) followed a cohort of children from age 4 to 7 years and found that inattention has been most strongly linked with negative academic outcomes with hyperactivity being more weakly so. Other studies have found a similar negative association

between inattention and academic achievement, including the systematic review by Polderman et al. (2010) described earlier, a study by Pingault et al. (2011), which followed the progress of a sample of 2000 students between the ages of 6 and 12, then followed them up to graduation, and a study by Duncan et al. (2007) who conducted a meta-analysis of the outcomes of a sample of 34,000 participants from six population-based large-scale longitudinal studies. The sample size of the six studies analysed by Duncan et al. was not as large as the present study and the outcome measures were different between studies. Probing the association between behaviour and academic outcomes, Sayal et al. (2015) analysed a population-based sample of 11,640 students whose behaviour was assessed by parents and teachers at the age of 7 using the Developmental and Wellbeing Assessment (DAWBA) and followed them up to the end of compulsory secondary education in England. The DAWBA provided scores for inattention and hyperactivity/impulsivity on a continuum which allowed the authors to investigate academic outcome for the full range of behaviours from no symptoms through to severe. They found a linear association between each one point increase in inattention symptoms and lower GCSE scores after adjusting for confounder variables. Inattention was a stronger predictor of later academic outcomes than hyperactivity/impulsivity. Most studies have considered hyperactivity and impulsivity as a single factor, however Tymms and Merrell (2011) analysed them separately and found that impulsivity was advantageous to academic outcomes after controlling for inattention, in particular verbal impulsivity (e.g. children blurting out answers to questions before the teacher has finished asking them).

The current study adds to previous research by investigating a large sample of 46,369 children over their first seven years of school using a measure of behaviour which provides separate scores for inattention, hyperactivity and impulsivity. It exceeds the sample size of studies reported to date and an advantage of this large sample size is that it includes sufficiently large numbers of children across the full range of scores on the behaviour rating scale to enable a detailed investigation of the association between academic progress over the first seven years of primary school in relation to the number of ADHD criteria met. Information about academic progress across the continuum of behavioural difficulties can be expected to have important messages for educational provision.

2. Method

Quantitative assessment data of children's early reading and mathematics development were collected at the start of school in England, when the children were aged four. Teachers' ratings of the children's behaviour were collected at the end of their first year of school (children aged 4–5 years). These data were matched to the statutory assessments taken by all children at the end of primary school in England at age 11.

2.1. Measures

2.1.1. Academic attainment at the start of school

Children's early reading and mathematics were assessed at the start of school using the PIPS On-Entry baseline assessment. The content of the assessment is based on skills and areas of knowledge that research has shown to be the best predictors of later success or difficulty at school (Tymms, 1999). It includes sections which assess vocabulary acquisition, concepts about print, phonological awareness, letter and word recognition, reading comprehension, understanding of mathematical concepts, counting, arithmetic and problem solving, shape identification and digit identification. It is computer-delivered and teachers assess one child at a time. The software presents questions verbally using recorded sound files. The content is arranged in series of sub-tests. Each sub-test is terminated after three wrong answers are given in a row or four in total. The pupils respond by either saying the answer or pointing to the answer on-screen and are not under time pressure.

The teacher records the pupils' answers on-screen. The internal reliability of the PIPS baseline assessment is 0.94 (CEM, 2001). Previous analysis has found strong correlations (up to 0.7) between the PIPS baseline assessment and later assessments of reading and mathematics attainment at age 11 (Tymms, Merrell, Henderson, Albone, & Jones, 2012).

Rasch measurement suggests that the items within the assessment form a unidimensional scale (Tymms et al., 2012) and therefore it was considered appropriate to use a single score that included both early reading and mathematics as a baseline measure of children's attainment at the start of school.

2.1.2. Behaviour at the end of the first school year

Rating scales were completed by class teachers based on their observations of pupils during the year. The items in the behaviour scales were almost identical to the diagnostic criteria for ADHD in DSM-IV with 9 items related to inattention, 6 items to hyperactivity and three items to impulsivity. Since the scales were intended for teachers of young children in the classroom setting, where necessary, the wording was adapted to reflect this. For example, the DSM-IV criterion 'Often does not follow through on instructions and fails to finish schoolwork, chores or duties in the workplace (not due to oppositional behaviour or failure to understand instructions)' was presented as 'Does not follow through instructions, fails to finish work.' See Appendix A for the behaviour rating scale items. Teachers rated each pupil's behaviour on a yes/no scale for each criterion and were asked to consider a criterion met only if the behaviour has persisted for at least six months and is considerably more frequent than that of most other children of the same gender and developmental level. Information about the reliability and validity of this scale can be found in Merrell and Tymms (2001).

2.1.3. English and mathematics at the end of primary school, aged 11

The National Curriculum in England is organized into Key Stages and when pupils are age 11, the end of primary school is also the end of Key Stage 2 of the national curriculum. English and mathematics attainment was measured using the end of Key Stage 2 statutory tests. These assessments are administered by class teachers but are marked externally. Until 2014, pupils' progress through the full National Curriculum was measured in levels with the expectation that pupils should have reached Level 4 at the end of Key Stage 2. The test results were available as sub-Levels (e.g. 4.0, 4.1, 4.2 and so on) referred to as 'fine-grained' levels. For the dataset analysed in this study, these 'fine-grained' levels ranged from 2.5–5.9. For further information about the End of Key Stage 2 assessments, see <http://www.bristol.ac.uk/cmipo/plugin/support-docs/ks2userguide2011.pdf>

2.1.4. Additional contextual variables

Further information about each pupil was included in the analyses: Gender, entitlement to free school meals, English as an additional language, and Income Deprivation Affecting Children Index (IDACI) score. The IDACI score is an area-level variable which relates to the child's home postcode (for more information, see Department for Communities and Local Government, 2011). These variables were provided by the Department for Education along with the end of KS2 attainment data.

2.2. Data source and sample

A sample of 46,369 children who started school in England in the 2000/2001 academic year was analysed in this study. The schools all participated in the PIPS (Performance Indicators in Primary Schools) monitoring system run by the Centre for Evaluation and Monitoring (CEM) at Durham University, UK. The PIPS system provides detailed information to schools about the attainment and progress of their pupils for self-evaluation purposes. The schools volunteered to participate in the PIPS system (see www.cem.org and Tymms (1999) for more information), and paid an annual registration fee to do so. As such, the

sample was self-selected. Participating schools assessed all of their pupils in the cohort at the start and end of the first year of school, and returned data to CEM for analysis and to receive normed pupil-level scores. As a consequence of this monitoring system, CEM holds a large dataset. Upon registration, the authorized school contact confirms that s/he has provided parents/guardians with sufficient information about the purpose of the PIPS monitoring system and they have been given the option to opt out if they do not wish their child to participate. Schools are also informed that anonymized pupil and school-level data will be used for research purposes.

The sample was based on pupils from 1812 state-funded primary schools in England from within the full PIPS data set. The sample schools consisted of those which registered to participate in PIPS in the 2000/01 academic year and had used the PIPS On-entry Baseline Assessment to assess the early reading and mathematics development of their new intake of pupils at the start of school (the Reception year in England) and whose class teachers had assessed their pupils' behaviour at the end of that first academic year. Schools with incomplete assessments at the end of the year were excluded from this study. At the end of primary school, when the pupils were aged 11, the cohort sat the statutory assessments; End of Key Stage 2 (KS2) statutory tests in English and mathematics. The pupils' statutory test results were provided from the National Pupil Database by the Department for Education and matched to the earlier PIPS data. All pupils are required to sit the statutory tests and therefore the proportion of pupils with missing data at this time-point is very small.

The national pupil database collates information at the pupil level about results on the statutory tests and background variables such as gender and home background and is available from the Department of Education, upon request, for research purposes. In addition to providing outcome measures, the National Pupil Database enabled us to examine the representativeness of the sample of children included in this study on the basis of information that we know about the children at age 11.¹ Pupils stay in the same schools up until the age of 11 so the representativeness of the data has been assumed to be similar at both the start of school and at age 11 although it should be noted that this is an assumption. The mean end of Key Stage 2 mathematics result from the national pupil database was 4.5 and the standard deviation was 0.83 (based on 582,110 pupils). This is extremely close to mean and standard deviation the study sample (4.51 and 0.80 respectively). A similarly close mean of 4.47 and standard deviation of 0.76 was found for end of Key Stage 2 English (based on 581,887 pupils) compared with the mean and standard deviation of the study sample (4.48 and 0.72 respectively). The mean IDACI score from the national pupil database was 0.22 and the standard deviation was 0.18, based on 567,941 pupils, which was the same as for the study sample. The percentage of pupils in the national database entitled to free school meals was 16.4%, which was slightly higher than the study sample of 14.77%. The percentage of pupils in the national database with English as an additional language was 15%, which is twice as many as in the study sample. Overall, the study sample reflected the full cohort of pupils included in the national pupil database with the exception of the percentage of pupils with English as an additional language where the percentage of pupils in the study sample was lower than the national average. This difference could reflect a more advantaged group of children in the sample; the percentage of children who were entitled to free school meals is slightly lower for the study sample again suggesting a slightly more affluent sample compared with the national average. However, the IDACI score was the same for the study sample and national database. These figures, along with other information about the study sample, are summarized in Table 1 in the Results section.

¹ Home postcodes were not available for all of the pupils at the start of school so this analysis of representativeness is based on the assumption that the home background at age 11 was similar to that at an earlier age.

Table 1
Variables included in multi-level models.

Variables	Sample mean of %	Sample SD	Sample range	National mean of %	National SD
End of Key Stage 2 Math	4.51	0.80	2.50 to 5.90	4.50	0.83
End of Key Stage 2 English	4.48	0.72	2.50 to 5.90	4.47	0.76
Inattention at age 5	1.47	2.25	0 to 9	N/A	
Hyperactivity at age 5	0.57	1.20	0 to 6	N/A	
Impulsivity at age 5	0.36	0.81	0 to 3	N/A	
Start of school academic attainment	49.66	9.67	18.94 to 89.98	N/A	
IDACI score	0.22	0.18	0.01 to 0.99	0.22	0.18
Male gender	50.88%			50.98% ^a	
Entitled to free school meals	14.77%			16.4%	
English additional language	7.19%			15%	

^a Percentage of age 11 males in national population in 2007 (Smallwood & DeBroe, 2009).

2.3. Statistical analysis

Graphical tools were used to explore the associations between inattentive, hyperactive and impulsive behaviours of children at age 5 and their academic attainment at age 11. We were particularly interested in visualizing whether there are linear associations between the number of criteria met on the behavioural items in the rating scale and academic attainment. Formal inferences for the associations between behaviours and academic attainments were based on multi-level model with schools as random effects. The multilevel model serves a dual purpose in that it allows the use of robust standard error for testing the associations between behaviours and academic attainments, and at the same time provides estimate of residual variance for calculating effect size. No further sensitivity analysis was performed for missing data because the analytical method is valid under the assumption of missing at random. This is applicable to all likelihood based methods and their results are consistent with multiple imputation. The analyses sought to answer the following questions:

- 1 What is the relationship between the continua of inattentive, hyperactive and impulsive behaviour exhibited by children in school at age 5, as identified by their class teachers, and their English and mathematics attainment at the end of primary school, age 11?
- 2 After adjusting for early reading and mathematics development at the start of school and contextual variables, what is the relationship between the children's behaviour at age 5 and their attainment at the end of primary school, age 11? If behaviour at age 5 continues to be associated with later academic outcomes what is the strength of that association?

3. Results and analysis

To investigate the first question about the relationship between varying degrees of behavioural difficulties at age 5 and attainment at age 11, pupils' attainment level are plotted against the number of criteria met on the behaviour rating scale. The results for inattention are shown in Fig. 1.

Fig. 1 illustrates the clear negative association between the number of criteria met on the inattention items in the rating scale and academic attainment at age 11. The box and whisker plots show the range of Key Stage 2 results attained for each number of criteria met and the median result. There is considerable variation in attainment for each number of inattention criteria met, and some children who were rated by their teachers as meeting several criteria had very high attainment at the end of KS2. Being rated as severely inattentive at age 5 did not determine a negative academic outcome. For mathematics, there was very little difference between the median and the inter-quartile range of academic attainment of children meeting eight or nine criteria relating to inattention. For English there was a more slightly more pronounced difference in the median scores at this top end of the behaviour rating

scale. The box and whisker plots for hyperactivity and impulsivity did not show such marked trends.

Next we investigate the association between behaviour and attainment after adjusting for prior attainment and contextual variables using multi-level models with pupils nested within schools. The variables included in the reported multi-level models are described in Table 1. Figures are given for the sample and, by way of comparison; figures are also given for the national sample. Data collected for this project and not collected nationally are marked as N/A.

Table 2 reports the multi-level models for the outcomes of English and Mathematics at age 11. The models were based on 46,369 pupils from 1812 primary schools.

The models reported in Table 2 are for the outcomes of Mathematics and English at age 11 years. The model coefficients are given with the 95% confidence intervals in brackets. Of the explanatory variables, inattention and impulsivity were statistically significant. Inattention was negatively associated with academic attainment at age 11 for both mathematics and English whereas impulsivity was positively associated. Although it is not shown in the models there was a near linear relationship between the number of impulsivity criteria met on the behaviour rating scale and the outcome measures.

The effect sizes for the difference in end of Key Stage 2 mathematics and English between children meeting a single point on the behaviour

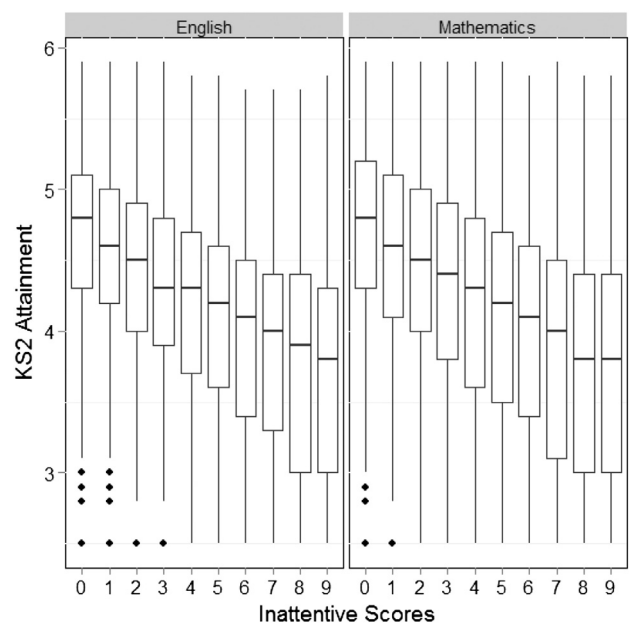


Fig. 1. Box and whisker plot showing attainment at age 11 by number of criteria met relating to inattention at age 5 (unadjusted).

Table 2
Multi-level models with academic outcomes at age 11 (end of Key Stage 2 Mathematics and English).

Variables	End of KS2 Mathematics estimate (95% CI)	End of KS2 English estimate (95% CI)
Inattention	−0.075 (−0.078, −0.072)**	−0.064 (−0.067, −0.061)**
Hyperactivity	−0.007 (−0.014, 0.001)	−0.005 (−0.012, 0.001)
Impulsivity	0.035 (0.026, 0.045)**	0.024 (0.016, 0.032)**
Male gender	0.233 (0.221, 0.244)**	−0.086 (−0.096, 0.076)
IDACI score	−0.234 (−0.276, −0.192)**	−0.271 (−0.308, −0.234)**
Free school meals (yes)	−0.085 (−0.102, −0.068)**	−0.121 (−0.136, −0.106)**
English additional language (yes)	0.314 (0.284, 0.344)**	0.288 (0.262, 0.314)**
Start of school academic attainment	0.044 (0.043, 0.045)**	0.040 (0.039, 0.041)**
Variance of random effects		
Schools (between school variability)	0.045	0.038
Pupils (within)	0.348	0.266

rating scales after adjusting for prior attainment and contextual variables are reported in Table 3. They are given with 95% Confidence Intervals in brackets and refer to increments of one point on the rating scale.

If a child met one additional criterion on the nine point scale related to inattention at the end of their first year of school, their progress toward mathematics and English attainment at age 11 from the start of school was 0.1 standard deviations below that of his/her peers of similar deprivation and the same sex. A child, meeting all nine inattention criteria, was almost one standard deviation lower in English and mathematics than a child meeting no criteria. This is statistically significant and of substantive importance. Impulsivity was associated with an academic advantage, although the effect size was much smaller than for inattention. If all three impulsivity criteria were met, the advantage amounted to 0.15 and 0.12 standard deviations difference in mathematics and English respectively. Hyperactivity was weakly negatively related to attainment although the association was not statistically significant.

4. Discussion

This study adds to the current knowledge about the impact of inattention, hyperactivity and impulsivity on children's long-term academic outcomes by considering the full range of ADHD symptoms and by differentiation between attention, hyperactivity and impulsivity. It is distinctive in its sample size and the detail of information available about children's levels of inattention, hyperactivity and impulsivity, reporting on children with mild difficulties and the association with academic attainment and progress.

The effect sizes from the multi-level models gave an estimation of the cumulative importance of behavioural difficulties identified at age

5 on progress toward mathematics and English at age 11. Inattention predicted substantially lower attainment. For children meeting all nine inattention criteria the effect size was 0.9 for English and mathematics, on average. The linear relationship between the number of inattention criteria met and academic attainment echoed the findings of Sayal et al. (2015), which used the DAWBA to assess behaviour at age 7 and followed the children up to the end of secondary school. The present study used a substantially larger sample and showed that this pattern of later risk of negative outcomes can be identified in children as young as five years and, as such, has potentially important implications for education. Hyperactivity was unconnected to attainment and impulsivity was weakly positively linked to attainment. For children meeting all three impulsivity criteria, the Effect Sizes were 0.15 and 0.12 for mathematics and English respectively. The picture is made more complete by looking at the box and whisker plots in Fig. 1, which shows the wide variation around the median scores for attainment in mathematics and English for each point on the inattentiveness criteria. Being rated as severely inattentive at a young age does not determine a child's progress; it simply suggests that academic progress is likely to be less than his or her peers with no behavioural difficulties. For example, there will have been some variation in the reliability of teachers' ratings as suggested by Merrell and Tymms (2001) and more consistent ratings might reduce the apparent variation in progress. On the other hand, a child's behaviour in the first year of school is likely to change; some children will have taken longer than others to settle into the school environment and may have displayed behavioural symptoms for that reason. Executive functions continue to develop throughout childhood and therefore the impact of inattention, hyperactivity and impulsivity displayed by children for whom development is delayed may lessen as they get older. Other children who were rated as meeting a high number of criteria on the behaviour rating scale may have found ways to manage their learning, leading to good progress. Whilst symptoms of hyperactivity are very apparent to teachers and peers in the classroom, they are not significantly related to academic progress and this is useful for educators to know, as is the small but weakly positive association between impulsivity and academic progress.

The study sample was very close to being nationally representative of pupils in English primary schools, although, the proportion of children with English as an additional language was lower in the study sample than across English schools as a whole. The level of deprivation was representative of the country as a whole but the percentage of children entitled to free school meals was slightly lower in the study sample compared with the rest of the country. This hints at the children in the study sample coming from very slightly more affluent home backgrounds. This paper has found that inattention is predictive of later academic outcomes and there may be an interaction with home background factors. This would be interesting to explore in future.

Whilst the study sample is a major strength in being able to investigate the long-term outcomes of proportionately small groups of children with severe behavioural difficulties, there are also limitations to the data set. One limitation is that we do not know how many children received a diagnosis of ADHD and subsequent treatment. Behaviour ratings for the full sample at age 11 in addition to their attainment would have been an interesting and useful variable to explore. For example, how did academic progress differ for those children who continued to experience behavioural difficulties compared with those whose symptoms were of a more temporary nature? Another limitation is that we do not have a measure of intelligence at the age of 11. Studies have found a relationship between attention and intelligence in children; Vaida, Hussain Mattoo, and Madhosh (2013) noted a statistically significant relationship between inattention and performance on Raven's Progressive Matrices. The lack of a measure of non-verbal ability as an indicator of intelligence at age 11 prevented exploration of the possibility that the low levels of inattention (meeting very few criteria on the teachers behaviour rating scale) were more a marker of low intelligence and general ability, and this was, in fact, the reason for their lower

Table 3
End of Key Stage 2 Mathematics and English effect sizes for each additional point on the behaviour scales (adjusted).

Behaviour	End of KS2 Mathematics effect sizes	End of KS2 English effect sizes
Inattention	−0.10 (−0.15, −0.06)	−0.10 (−0.14, −0.06)
Hyperactivity	−0.01 (−0.05, 0.03)	−0.01 (−0.05, 0.03)
Impulsivity	0.05 (0.01, 0.09)	0.04 (0.00, 0.08)

attainment. Similarly, the lack of information about other emotional or behavioural problems such as aggression and conduct disorder also limits the conclusions. It is possible that some children displayed such symptoms and they could have influenced their academic outcomes. However, impulsiveness is more strongly associated with these problems than inattention, and impulsiveness was not strongly predictive of negative academic outcomes.

In conclusion, the findings suggest that children with quite modest levels of inattention are at risk of poor academic outcomes, which adds to current knowledge. Such children could be identified by class teachers and they could benefit from appropriate school-based interventions. These findings are also important to parents who could work in conjunction with their child's teacher to provide a consistent approach to the implementation of interventions.

Appendix A

A.1. Inattention

- 1 Makes careless mistakes in school work or other activities.
- 2 Has difficulty sustaining attention in tasks or play activities.
- 3 Does not seem to listen when spoken to directly.
- 4 Does not follow through instructions, fails to finish work.
- 5 Has difficulty organising tasks and activities.
- 6 Is reluctant to engage in tasks which require sustained mental activity.
- 7 Loses equipment necessary for activity e.g. pencils, books.
- 8 Is distracted by extraneous stimuli.
- 9 Forgetful in daily activities.

A.2. Hyperactivity

- 1 Fidgets with hands or feet or squirms in seat.
- 2 Leaves seat in classroom or in other situations where remaining seated is expected.
- 3 Often runs about excessively in situations in which it is inappropriate.
- 4 Has difficulty in playing quietly.
- 5 Is often 'on the go' as if driven by a motor.
- 6 Talks excessively.

A.3. Impulsivity

- 1 Blurts out answers before questions have been completed.
- 2 Has difficulty awaiting turn.
- 3 Interrupts or intrudes on others e.g. pushes into conversations or games.

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