ADHD and academic attainment; is there an advantage in impulsivity?

Peter Tymms[1]* and Christine Merrell[2]

[1]* School of Education, Leazes Rd, Durham University, Durham, DH1 1TA, UK

e-mail: p.b.tymms@dur.ac.uk tel +44 191 3348413 fax +44 191 3348311

[2]Centre for Evaluation and Monitoring, Mountjoy 4, Stockton Rd., Durham University, England

christine.merrell@cem.dur.ac.uk

Abstract

Pupils diagnosed with ADHD and pupils with ADHD symptoms tend to do less well at school than their symptom-free peers. This has been found to be particularly true for predominantly inattentive pupils. This paper aimed to establish the importance of inattention, hyperactivity and impulsivity to the academic progress of young children. A large dataset which held children's reading and maths attainment at the end of their first year at school, as well as teachers' ratings of ADHD-related behaviours based on the DSM-IV criteria was analysed. Inattention was strongly linked to under-attainment whilst impulsivity was positively related to attainment for similar levels of inattention. The item "Blurts out answers" on the teachers' rating scale was particularly important. When impulsivity acts as an overt sign of cognitive engagement it seems to have a positive function. This raises questions about the inclusion of the "blurting out" item in the ADHD DSM criteria.

Keywords

ADD/ADHD, Attention, Reading, Mathematics, Impulsivity

1 Introduction

Children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) have been found to attain lower academic levels than their peers (Frazier, Youngstrom, Glutting and Watkins, 2007). This trend also applies to children who are severely inattentive, hyperactive and impulsive but do not have a formal diagnosis of the disorder (McGee, Prior, Williams, Smart and Sanson, 2002; Merrell and Tymms, 2001).

There are currently three recognized subtypes of ADHD (American Psychiatric Association, 1994): Predominantly Inattentive, Predominantly Hyperactive/Impulsive and Combined. Analysis of data from children in elementary schools has revealed that inattention is particularly related to academic underachievement (Effect Size = -1.07 at age 7), hyperactivity/impulsivity has less of a negative association (Effect Size = - 0.58), (Merrell and Tymms, 2001). Karmos, Scher, Miller and Bardo (1981) found that impulsivity alone is negatively related to reading and mathematics.

The causes of ADHD are thought to be complex and multifactorial (Sergeant, Geurts, Huijbregts, Scheres and Oosterlaan, 2003). It has consistently been associated with weaknesses in executive function domains (Willcutt, Doyle, Nigg, Faraone and Pennington, 2005) although the links between measures of executive function and ADHD are not seen as strong enough to regard executive function deficits as a "necessary nor sufficient cause of all cases of ADHD" (Willcut et al. 2005). Sonuga-Barke (2005) suggested that motivational development may also be important.

Behavioural inhibition enables the processing of information by the executive functions to occur by preventing individuals from reacting to a stimulus too rapidly. Barkley (1994 and 1997) suggested that behavioural inhibition in individuals with ADHD is impaired, which leads to impaired executive functions, causing an individual to appear hyperactive and impulsive. These individuals are also likely to be inattentive. Whether or not the Combined and Predominantly

Inattentive subtypes are variants of a single disorder has been debated. Barkley suggested the attention deficit associated with the Predominantly Inattentive subtype could be due to slow information processing and problems with focused and selective attention whereas the attention deficit in the other subtypes could be due to a deficit in sustained attention and increased distractibility brought about by impaired behavioural inhibition. Milich, Balentyne and Lynam (2001) reviewed the literature and concluded that the Combined and Predominantly Inattentive subtypes are distinct disorders. In their longitudinal study Lahey, Pelham, Loney, Lee and Wilcutt (2005) found that the Predominantly Hyperactive/Impulsive subtype tended to be unstable, and a significant proportion of young children with that diagnosis shifted to the Combined subtype as they aged.

More recent causal models (Sonuga-Barke, 2005) have attempted to account for the heterogeneity seen within ADHD by proposing that ADHD might be explained by a combination of the cognitive dysfunction model and motivation-based dysfunction models. They are based on the consistent findings that many children with ADHD are averse to delay, have motivational difficulties in relation to delayed rewards and find it difficult to concentrate for extended periods of time whilst acknowledging that in certain circumstances a child with ADHD can delay a response. However, an impulsive child typically has difficulty succeeding in an environment that requires them to delay their responses in pursuit of a later reward. In situations when delay cannot be reduced, an impulsive child tries to divert their attention to something else, which gives the impression that they have attentional and hyperactivity difficulties.

While these theories suggest pathways for the cause of ADHD symptoms, it is not clear which features lead to underachievement in school. Is it possible that the problem of sustaining attention can fully explain poor attainment levels and that impulsivity and/or hyperactivity are either not relevant or advantageous to school attainment? Williams and Taylor (2006) suggested

several advantages to hyperactivity and impulsivity which they split into individual and group factors. They do not note any individual factors which seem beneficial to schooling although, "testing limits" could be seen as beneficial to the class as a whole.

Although ADHD behavioural characteristics are often reported on two dimensions, recent studies have suggested that the symptoms of hyperactivity and impulsivity included in the DSM-IV diagnostic criteria for ADHD form two distinct factors (Smith and Johnson, 2000; Merrell and Tymms, 2005). Further, there is evidence that impulsivity itself is not a unitary construct (Evenden, 1999). White, Moffitt, Caspi, Bartusch, Needles and Stouthamler-Loeber (1994) conducted a longitudinal study of boys whose impulsivity was assessed when they were on average between 12 and 13 years old. The eleven measures were weakly related to one another, the highest correlation being 0.33. Factor analysis identified two dimensions which were labeled Cognitive and Behavioural. Cognitive Impulsivity was associated with poor performance on tasks that required mental control and the ability to shift between tasks. Behavioural impulsivity reflected undercontrolled and disinhibited behaviour. Cognitive Impulsivity was assessed by tasks and Behavioural Impulsivity by rating scales, prompting the authors to note that the factor analysis may have picked out modes of assessment. A different perspective was taken by Dickman (1990) who, looking at gambling, distinguished between functional and dysfunctional impulsivity.

This paper investigates the separate effects of inattention, hyperactivity and impulsivity on the attainment of children during their first year at school.

2 Material and Methods

2.1 Data

Data for this study were gathered from schools who were taking part in the Performance Indicators in Primary Schools (PIPS) project run by the Centre for Evaluation and Monitoring

(CEM) at Durham University, UK. The PIPS project monitors the progress of children as they move through elementary schools (Tymms, 1999). The data are collected by schools and returned to the Centre for analysis. When schools register to participate, they complete and return a form which states that they have satisfied themselves that parents/guardians have been given sufficient information about the purpose of the project and 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.

All the schools pay an annual fee to participate (either individually or through their district) and receive feedback. Schools tend to assess their pupils on a regular basis, which enables them to monitor progress and, with just over 4,000 schools participating annually, CEM holds a large, longitudinal dataset. The data have been found to be representative of England by school size, deprivation, sex, ethnicity and statutory assessment outcomes.

2.2 Sample

The sample comprised all 12,251 pupils from English schools who were assessed when they started school and at the end of the academic year 2005/06, and for whom data were available on all relevant variables. They were aged 4.5 years on average in the September when they started.

2.3 Assessments

Pupils were initially assessed on early reading and mathematics using a computer-delivered assessment by teachers working with one pupil at a time. The computer program, known as the PIPS BLA (baseline assessment) presents questions verbally using recorded sound files. The assessment is made up from a series of sub-tests. Each 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. When administered at the end of the year, the assessment takes off from just

before the point where the pupil faltered in each sub-test at the start of the year. The assessment has high reliability and good predictive validity (Tymms, 1999).

The end of year PIPS BLA included an optional section on behaviour. This was completed by class teachers based on their observations of pupils during the year. The items in the behaviour rating scale were almost identical to the diagnostic symptoms for ADHD in DSM-IV with 9 items related to inattention, 6 items to hyperactivity and three items to impulsivity. Since the scale was intended for young children in the classroom, the DSM-IV items were modified slightly (Merrell and Tymms, 2001). 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 modified to 'Does not follow through instructions, fails to finish work.' Teachers rated the frequency with which each child met each criterion by moving an on-screen slider to a point ranging from "never" to "always". No other verbal descriptors were attached. The rating was recorded on a 10-point scale. Rasch measurement reliabilities are reported in Table 1.

Insert Table 1 here

2.4 Analyses

Theoretical (Barkley, 1997) and empirical work (Merrell and Tymms, 2005) suggest that the 9 items relating to inattention in the DSM-IV include two which stand out as being less associated with the overall inattention scale than the rest ("difficulty sustaining attention" and "easily distracted"). These are omitted from the analyses and the term "Inattentiveness A" distinguishes it from the full 9-item measure.

Initially the correlations between inattention, hyperactivity and impulsivity were established. Then for each of the three scales, Inattentiveness A, hyperactivity and impulsivity,

the sample was split into three equal sized groups constituting high, medium and low scores which acted as the independent variables in a Univariate General Linear Model (GLM) with mathematics as the outcome. Sex was also included as an independent variable and all two way interactions were included. This was repeated with reading as the outcome.

One threat to the validity of the GLM analyses is the clustering of pupils within schools. A more sophisticated analysis was therefore carried out by constructing Multi-Level Models (MLMs) taking into account the within school clustering of pupils.

Because, as noted earlier, impulsivity is not a well-defined construct, separate investigations were carried out into the relevant items:

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.

Three equal sized groups (scores 0-1, 2-3 and 4+ for the three items) were created and a series of GLMs were run with reading and mathematics as the outcomes. The creation of three large groups ensured small errors of measurement whilst paralleling the earlier analysis. The maximum number of groups could have been 10, the number of response categories, but there would then have been some small groups. Inattentiveness was controlled by introducing it as a covariate in the model and each item relating to impulsivity was used as a factor. The purpose was to estimate the relative importance of the items to attainment and this was done by comparing the F statistic and the difference between the attainment scores of the three groups. Once one item stood out the full 10 point scale was analysed.

Finally, because the main relationships were established with a full range of data the analyses were repeated with a sample which was restricted with a select group chosen to correspond to a clinically relevant set of pupils

3 Results

3.1 Correlations

The correlations between the measured components of ADHD are shown in Table 2. They reached 0.82 for the correlation between impulsivity with hyperactivity and went down to 0.59 for Impulsivity with Inattentiveness A.

Insert Table 2 here

3.2 General Linear Models

Table 3 shows the analysis with mathematics as the outcome. Inattentiveness A was a very significant ($p<.0005$) independent predictor, as were impulsivity and sex, but hyperactivity and all two way interactions were non-significant. Boys slightly outperformed girls. The links between mathematics, Inattentiveness A and impulsivity are shown in Figure 1. The chart indicates that the higher the Inattentiveness A measure, the lower their mathematics scores. The scale on the vertical column is a T-score (mean = 50, standard deviation = 10) and it indicates that the difference between the high and low inattentiveness groups was about -10 points. The Effect Size (ES) was -1.19 calculated using the pooled standard deviation. The chart also shows impulsivity to be an advantage to maths scores when children of equal Inattentiveness A are considered (ES=0.40).

Insert Table 3 here

Insert Figure 1 here

Very similar results were found for reading although, unlike mathematics, hyperactivity was a significant independent variable. Higher hyperactivity was associated with lower attainment although the ES was small (>-0.2). None of the two-way interactions were significant. The key relationship is shown in Figure 2. As with mathematics, the ES between high and low inattention was -1, and between high and low impulsivity was 0.43.

Insert Figure 2 here

3.3 Confirmatory Analyses Using MLMs

The MLMs exactly paralleled the GLM analyses except that pupils were nested within schools and linear relationships were assumed for the three ADHD characteristics. The results were substantially the same as the GLMs. Inattentiveness A was very significantly associated with lower scores and impulsivity was very significantly linked to higher scores. Two significant weak interactions appeared; a combination of hyperactivity with inattentiveness, and a combination of hyperactivity with impulsivity were both associated with less positive attainment outcomes. For reading only, the positive link to impulsivity was less pronounced for females.

3.4 Forms of Impulsivity

Using the three impulsivity items the children were divided into tertiles. The mathematics and reading outcomes were analysed in GLMs in relation to these three groups in combination with Inattentiveness A. The results are summarized in Table 4. The F values for all 6 models indicate statistical significance but the most statistically and substantively significant by far were for “Blurts out answers”.

Insert Table 4 here

A key relationship is illustrated in Figure 3. It shows the tendency for pupils' higher mathematics scores to be associated with higher ratings on the "Blurts out answers" item whilst controlling for Inattentiveness A. The figure includes the number of cases on which each point was based. Severity rating 6 was only checked for 2 pupils and whilst its position appears to challenge the trend it can safely be ignored because its confidence intervals overlap the general trend of the other points. Quite why rating 6 was so unpopular is unclear.

Insert Figure 3 here

The average mathematics score of those given a rating of 0 on the "Blurting Out" item was 48 (n=3231) and was 55 (n=255) for those given a rating of 9, (ES=0.77 using the pooled SD) indicating a substantive as well as a statistically significant advantage.

3.5 Relevance to clinical cases

To what extent is the finding from the school-based sample of this paper relevant to those with a clinical diagnosis? Ford, Goodman and Meltzer (2003) estimated that 2.2% of children aged 5 to 15 had ADHD in the UK. Using this figure as a guide 2.2% of cases with the highest inattentiveness scores were compared with the full sample. Whilst 85% of the full sample were rated 0 (never) to 4 on the "Blurts out" item, just 47% of the selected cases had such low ratings. In this restricted group, the same pattern was found as in the whole sample; there were significant weak positive correlations between "Blurting out answers" and attainment in reading and maths (0.23, $p<.05$ and 0.24, $p<.05$ respectively) after controlling for Inattentiveness A.

4 Discussion

The analyses suggest that there is some academic advantage for young children in being impulsive but alternative hypotheses of varying plausibility are discussed below. This is followed by a section which explores the issue of different types of impulsivity and an explanation for the main finding is suggested. The finding's relevance to clinical cases is also discussed. Finally, the implications for future research and for children with ADHD characteristics are outlined.

4.1 Alternative hypotheses

1. Could the main finding be a Type I error? This seems unlikely given the large sample size.

2. Could sex differences have generated the findings? If so, significant interactions for sex might be expected in the GLMs. These were not found. The significant but weak interactions involving sex in the MLMs were inconsistent and the effect size too small to threaten the main finding.

3. Could the halo effect be the cause of the main finding? A halo would imply that low achieving children would be given higher ratings for inattentiveness and impulsivity than appropriate. But to produce the main finding the attentive, high achieving children would need higher impulsivity scores than appropriate. This is possible but counter intuitive.

5. Could an unmeasured variable, such as the confidence and knowledge of some young children be acting as the key causal factor? This is a possibility; only intervention studies could firmly establish a direct causal link.

6. Could attainment be the cause of impulsivity and/or attentiveness? Again, without additional information it is not possible to distinguish the direction of causality.

4.2 Types of impulsivity

Dickman (1990) distinguished between functional and dysfunctional impulsivity. The former relates to quick decision making which is appropriate to the situation and the latter to decisions with negative consequences to the individual. Whilst this is a useful perspective with some backing (Vigil-Colet, Morales-Vives and Tous, 2008) the impulsivity items in the DSM-IV do not map directly to Barratt's (1994) conception of functional impulsivity (Dickman, 1990). Neither does White et al. (1994)'s distinction between cognitive and behavioural impulsivity seem to help since the DSM items seem most closely aligned to Behavioural Impulsivity being based on teachers' ratings of behavioural control but blurting out is surely linked to Cognitive Impulsivity (mental effort and mental control).

Although three DSM-IV impulsivity items load on a single factor (Merrell and Tymms, 2005; Oades, Lasky-Su, Christiansen and Faraone et al, 2008) in the present study, "Blurts out answers" stood out as being the most positive item in relation to attainment. Oades et al. commented: "Of interest is the item "blurts out answers before the question is finished" ... This item could be construed as an example of impulsive behaviour overlying a cognitively impulsive decision."

4.3 Some possible explanations

To explain why inattention might be negatively associated with learning (memory and understanding) is not hard. If a child does not take notice of what is going on and does not listen s/he won't absorb information as well as others. Impulsivity as a positive academic attribute is more difficult to reconcile but it might be an indication of cognitive engagement which Mayer (2004) claimed is the key to learning. Perhaps children who become excited by ideas and cognitively engaged tend to lodge ideas more firmly in their minds. An overt manifestation of this may be the tendency to blurt out answers. This relationship leads to the question: Does

blurting out signify greater cognitive engagement or does it actively contribute to learning? Whatever the answer, if the link between impulsivity and attainment is real, it adds another group advantage of impulsivity to individuals to those listed in Williams and Taylor (2006). The excitement of one individual may encourage others to become engaged. Or perhaps the one who cannot help himself (sic) saying something can force the group to face a reality which none dared declare openly. In evolutionary terms it may have been advantageous to have a small proportion of individuals who blurted out.

5 Discussion

The main finding of this paper, that there is academic advantage in being impulsive and specifically blurting out answers, has a number of implications, but it is a tentative finding. It would be valuable to see if other studies, particularly involving older individuals, agreed.

More important investigations would involve the manipulation of impulsive behaviour in the form of blurting out. A situation is needed where attentiveness can be maintained at a constant level whilst impulsivity is changed. Two possibilities are suggested. The first involves the kind of scenario encountered by young children in puppet shows such as Punch and Judy. Audiences are thoroughly engaged and puppets deliberately encourage blurting out. It would be possible to set up an experimental situation in which two near identical puppet shows are created which differ only in their encouragement of blurting out. Later recall and comprehension would be the criteria.

A second possibility is an interactive computer activity in which the subject is exhorted to shout out his or her choice at certain points. Later recall and understanding would be used to judge the impact of shouting out. The two experiments together would allow a distinction to be

made between the value of simply shouting out an answer on command as opposed to blurting out impulsively.

In both experiments the "created" impulsivity may not be identical to that identified by the teachers' ratings of 'blurting out answers'. Be that as it may it is important to test the hypothesis that learning can be increased by encouraging blurting.

The possible advantage to a group of an individual's impulsivity could be explored using large scale datasets with information on the ADHD characteristics of children linked to attainment levels across many classrooms on at least two time points. Complex modelling could then explore the hypothesis that the presence of impulsive individuals is advantageous to the classes' learning, but such modelling is complex and non-experimental. Ideally, research would involve moving impulsive individuals and controls between classes in a clustered randomised controlled trial, but the logistics are daunting.

Treating the symptoms of ADHD with medication does not lead to the expected educational gains (Purdie, Hattie and Carroll, 2002) although methylphenidate and atomoxetine have been shown to be effective in reducing the core symptoms of ADHD (Taylor, Kendall, Asherson, Bailey, Bretherton, Brown et al., 2009; Weiss, Tannock, Kratochvil, Dunn and Valez, 2005). Taylor et al. also failed to find firm evidence of classroom strategies which improve the learning of children with ADHD. If the fundamental barrier to the academic achievement of children with ADHD is a combination of inattentiveness and lack of cognitive engagement, then there is a clear challenge. Can classroom approaches be developed which capitalize on the apparent advantage of blurting out?

Whatever further investigations discover, this paper points to a clear problem with the DSM-IV criteria for ADHD. The blurting out item should be removed.

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Table 1

Reliabilities of Items and Persons of the ADHD 10-point Scale (Sample A) Derived from Rasch Measurement

	Item Reliability	Person Reliability
Whole scale	1.00	0.93
Inattention	1.00	0.93
Inattention A*	1.00	0.91
Hyperactivity	1.00	0.83
Impulsivity	0.83	0.82

* Inattention A is the inattention scale with "difficulty sustaining attention" and "easily distracted" removed.

Table 2

Correlations

	Inattentiveness A	Hyperactivity
Hyperactivity	0.74	
Impulsivity	0.59	0.82

n~12, 200

Table 3

General Linear Model with Mathematics as the Outcome

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	252125.952(a)	25	10085.038	124.157	.000
Intercept	7225229.432	1	7225229.432	88949.809	.000
Inattentiveness A	94557.929	2	47278.964	582.051	.000
Hyperactivity	365.953	2	182.977	2.253	.105
Impulsivity	4522.549	2	2261.274	27.839	.000
Sex	3879.411	1	3879.411	47.759	.000
Inattentiveness A *Hyperactivity	226.021	4	56.505	.696	.595
Inattentiveness A * Impulsivity	610.058	4	152.515	1.878	.111
Inattentiveness A * Sex	276.179	2	138.090	1.700	.183
Hyperactivity * Impulsivity	245.137	4	61.284	.754	.555
Hyperactivity * Sex	203.227	2	101.614	1.251	.286
Impulsivity * Sex	192.764	2	96.382	1.187	.305
Error	983835.492	12112	81.228		
Total	31714560.481	12138			
Corrected Total	1235961.445	12137			

R Squared = .204 (Adjusted R Squared = .202)

Table 4

Links between the Impulsivity Items and Outcome Measures

Item	Outcome	F* value	High	Middle	Low	Hi-Lo
Often blurts out answers	Reading	114	52.0	50.7	48.7	3.3
Often interrupts or intrudes	Reading	27	50.9	50.9	49.5	1.4
Often has trouble waiting turn	Reading	15	50.9	50.8	49.7	1.3
Often blurts out answers	Maths	137	52.4	51.2	49.0	3.4
Often interrupts or intrudes	Maths	39	51.4	51.4	49.6	1.8
Often has trouble waiting turn	Maths	21	51.2	51.0	49.8	1.4

* The F statistic from GLM with 2 degrees of freedom

Figure Captions

Figure 1. Mathematics, Inattentiveness and Impulsivity

Figure 2. Reading, Inattentiveness A and Impulsivity

Figure 3. Mathematics Related to “blurts out answers” Controlling for Inattention

Figure 1

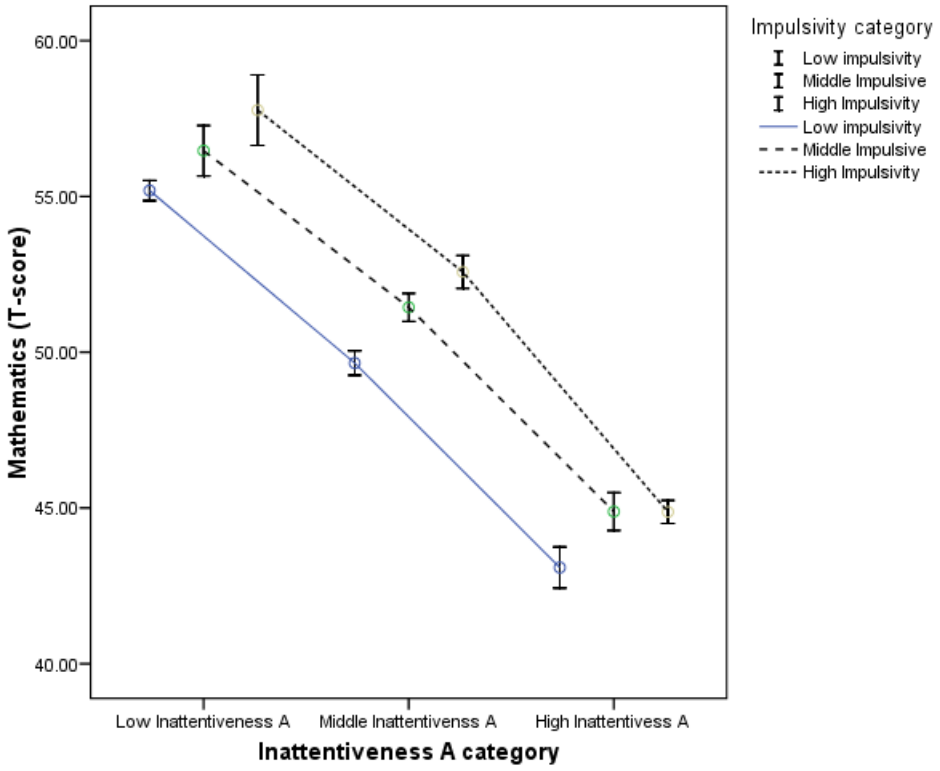

Figure 2

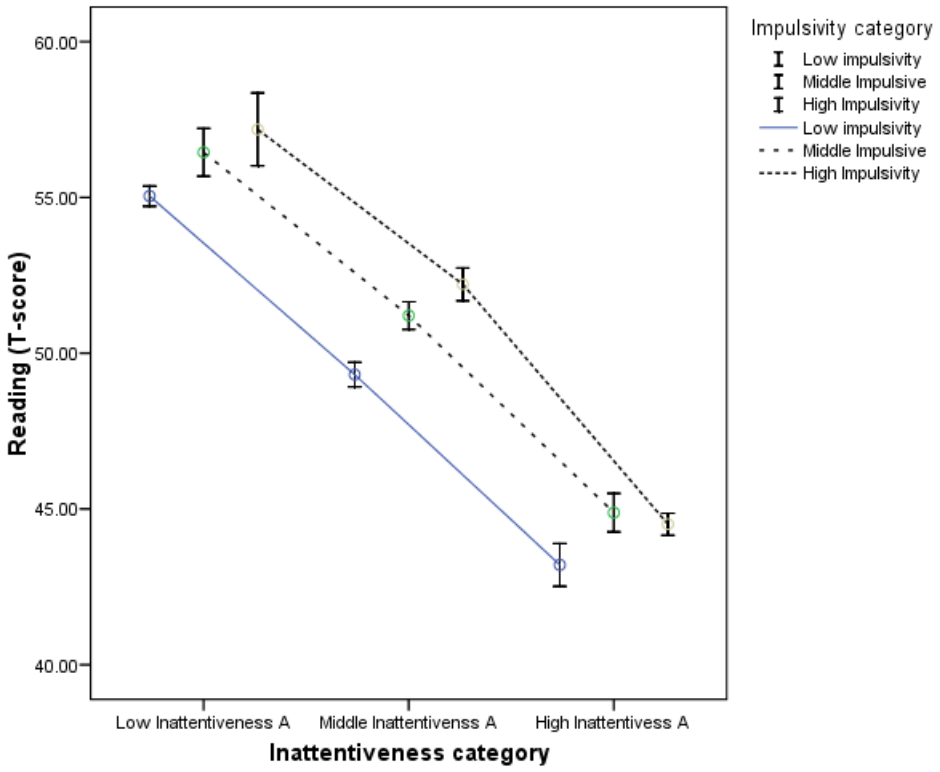

Figure 3