Chapter 4

The Specificity of Intra-Individual Variability for ADHD compared to RD

Abstract

Background: Increased intra-individual variability (IIV) is considered characteristic of attention deficit hyperactivity disorder (ADHD), although there is evidence of increased IIV in other psychiatric disorders. This study focused on the specificity of IIV in ADHD compared to reading disorder (RD), a frequently occurring comorbid disorder in ADHD. It was also tested whether IIV in ADHD and RD differ in reaction time (RT) distribution and whether IIV in ADHD and RD depend on the cognitive domain studied. **Method**: To study IIV in the RT distribution, central tendency measures, ex-Gaussian and Intra-individual Standard Deviation (ISD) measures were used as IIV measures. These measures were computed for three cognitive domains: two choice processing, inhibition and lexical processing in children with ADHD (n=24), children with ADHD+RD (n=26), children with RD (n=41) and control children (n=26) aged between 8 and 12. **Results**: ADHD and RD were associated with increased IIV on all IIV measures except sigma, which was associated only with RD. Both ADHD and RD were more variable as assessed by the SD during lexical processing compared to two choice processing. In contrast, RD, but not ADHD, was associated with greater variability as determined by sigma and tau, during lexical processing compared to two choice processing. Domain did not differentiate between ADHD and RD for the ISD measures. **Conclusions**: The current study shows a consistent overlap in increased IIV between ADHD and RD over the entire RT distribution. There was evidence that IIV varies with cognitive demands and differentiates ADHD from RD. IIV in RD was associated with lexical processing, whereas IIV in ADHD occurred in each cognitive domain. **Keywords**: intra-individual variability, attention-deficit/hyperactivity disorder, reading disorder, two choice processing, inhibition, lexical processing.

De Jong, C.G.W., Oosterlaan, J., Geurts, H.M., & Sergeant, J. The Specificity of Intra-Individual Variability for ADHD compared to RD. (*submitted for publication*).

INTRODUCTION

A consistent finding in the ADHD literature is that reaction times (RT) of children with ADHD are more variable than those of their normal developing peers (Castellanos et al., 2005; Klein, Wendling, Huettner, Ruder & Peper, 2006; Vaurio, Simmonds & Mostofsky, 2009). This phenomenon is termed intra-individual variability (IIV, Klein et al., 2006) and considered a potential candidate endophenotype for ADHD, which is an essential link between phenotype and genotype of the disorder (Castellanos & Tannock, 2002).

There are various IIV measures described in the ADHD literature. IIV in ADHD is often operationalised using central tendency measures of the normal RT distribution such as the standard deviation of RT (SD) and the coefficient of variation, which equals the SD divided by the mean reaction time (MRT; Klein et al., 2006). ADHD is associated with larger SDs and coefficients of variation than typically developing children (Klein et al., 2006). However, the SD and coefficient of variation do not give insight in the RT distribution, for example is a large SD the result of increased variability in the whole RT distribution or is the large SD the result of some extremely slow or fast responses which impact the SD value? Various studies in patients with ADHD have shown a pattern wherein the majority of responses cluster around the mean, alternating with occasional responses with unusually long RT (Hervey et al., 2006; Leth-Steensen, King Elbaz & Douglas, 2000). The ex-Gaussian distributional model takes into account extremely slow responses and enables studying the right, slow tail of the RT distribution. This tail of the RT distribution contains the extremely slow responses as assessed by tau (Hervey et al., 2006; Leth-Steensen et al., 2000). Various studies have demonstrated that children with ADHD have larger tau than typically developing children (Hervey et al., 2006; Leth-Steensen et al., 2000; Vaurio et al., 2009). In addition, ADHD has been associated with increased sigma indicating increased IIV in the normal distribution, when extreme RTs are removed. Another measure that tests IIV is the intra-individual standard deviation (ISD), which allows studying of IIV in both the fast and slow portions of the RT distribution and the entire RT distribution. Using ISD, Williams, Strauss, Hultsch and Tannock (2007) observed, in contrast to the observations of tau in ADHD, that ADHD was not associated with increased IIV in the *slow* portion of the RT distribution, but it was in the *fast* portion of the RT distribution. Increased IIV in the slowest responses was associated with the comorbidity of ADHD and Reading Disorder (RD) (Williams et al., 2007). These findings suggest that ADHD differs in IIV in the RT distribution, which may be influenced by comorbid disorders, such as RD.

Some studies have reported increased IIV in children with comorbid disorders of ADHD, such as high functioning autism (HFA), tic disorder or children with RD, which questions the specificity of IIV deficits for ADHD (Borella, Chicherio, Re, Sensini & Cornoldi, 2011; Geurts et al. 2008; Williams et al., 2007). In this study, we focused on the specificity of IIV deficits for ADHD compared to RD. Two studies compared ADHD to RD on IIV (Borella et al., 2011; Williams et al., 2007). Williams et al. (2007) found that ADHD was associated with ISD in the fast portion of the RT distribution. RD alone was not associated with IIV abnormalities. The ADHD+RD group showed increased IIV in the *overall* RT distribution as well as in the *slow* tail compared to typically developing children (Williams et al., 2007). Borella et al. (2011), in contrast, reported increased IIV in both children with only ADHD and children with only RD compared to typically developing children in a simple reaction time task and a handwriting task. Unfortunately, Borella et al. (2011) did not include a comorbid ADHD+RD group, hence, whether the ADHD+RD group has a different IIV profile than that of single diagnosis groups: ADHD-alone and RD-alone, could not be determined. A different IIV profile in the ADHD+RD group might indicate that ADHD+RD is another clinical entity than ADHD or RD alone (Rucklidge & Tannock, 2002). Alternatively, when the comorbid ADHD+RD group does not have a different profile than that of the ADHD and RD groups alone, comorbid ADHD+RD might be functionally an addition of both ADHD and RD. Thus for a thorough study of specificity of IIV in ADHD compared to RD to be achieved, inclusion is required of both the single diagnosis ADHD and RD groups and a comorbid ADHD+RD group.

Increased IIV in ADHD and RD has been observed in tasks known to tap in key processes that are deficient in these two disorders: executive functioning (EF) and lexical processing. It is unclear whether IIV findings in ADHD are a consequence of impaired EF or point to a separate impairment in ADHD, since IIV in ADHD is often measured using primarily EF tasks such as tasks tapping inhibition processing (Klein et al., 2006). IIV in RD may also depend on impaired key processes since IIV in RD was associated with IIV in a lexical processing task (Marinus & De Jong, 2010). The present study also targets to unravel whether IIV in ADHD and RD is dependent on cognitive domain.

The purpose of our study was to answer two questions:

1. Is increased IIV specific to ADHD compared to RD and ADHD+RD?
2. Is increased IIV independent of studied cognitive domain?

In order to answer the first question, we included an ADHD, ADHD+RD, RD and a typically developing group. For the second question, we compared IIV in an inhibition and a lexical processing task to a two choice processing task which was considered as baseline condition. To test whether IIV differed along the RT distribution between ADHD and RD, we included central tendency measures of IIV, measures of IIV based on the ex-Gaussian distributional model and ISD measures.

METHOD

For a detailed description of the sample and assessment procedure, see De Jong et al. (2009). Written informed consent was obtained from the parents and from the child if aged 12 years. The study was approved by the local research ethics committee.

Participants

The sample consisted of 24 children with ADHD, 41 children with RD, 29 children with ADHD+RD and 26 typically developing children. The final sample consisted of 120 children aged 8 to 12 years.

All participating children were screened for the presence of ADHD-Combined Type (ADHD-C) with the Disruptive Behaviour Rating Scale completed by both the parent and the teacher (DBD; Pelham, Gnagy, Greenslade & Milich, 1992; Dutch translation: Oosterlaan, Scheres, Antrop, Roeyers & Sergeant, 2000). To confirm an eventual diagnosis of ADHD-C, the Diagnostic Interview Scale for Children was administered to parents of all children (PDISC-IV; National Institute of Mental Health (NIMH), Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000; Dutch translation; Ferdinand, Van der Ende, & Mesman, 1998).

All children were screened for RD using two Dutch technical word reading tests, the One Minute Test (OMT; Brus & Voeten, 1973) and the Pseudo-word Reading Test, (PRT; Van den Bos, lutje Spelberg, Scheepsma & De Vries, 1999) and using a text reading test, the Text Reading Test (TRT; Visser, Laarhoven & Ter Beek, 1998).

Children were excluded when they had another comorbid diagnosis than ODD, stated by a clinician or diagnosed on the PDISC-IV. All children had an IQ ≥80. See Table 4.1 for patient characteristics.

Medication

Thirteen children in the ADHD only group and nine children in the ADHD+RD group were on stimulant medication. Children were off stimulant medication for at least 48 hours before testing. Children were not on other types of medication.

Measures

IIV measures were obtained in three domains: two choice processing, inhibition and lexical processing.

Two choice processing. RT data of the first block of the Stop task were used to investigate IIV in two choice processing, see for details of the used Stop task De Jong et al. (2009). The first block contained 64 trials. Subjects were required to indicate the position of a cartoon aircraft that was displayed to the left or right of a fixation point on a computer screen by pressing one of two response buttons that corresponded to the direction in which the plane pointed.

Inhibition (EF task). RT data of the second block of the Stop task were used to study whether IIV is associated with inhibition and contained 64 trials of the same cartoon aircraft similar in block 1. In 16 of these trials a cross was pseudo-randomly imposed on the cartoon aircraft. Children were instructed to inhibit their responses to the cartoon aircraft, when they saw a cross imposed on the aircraft.

Table 4.1. Mean, standard deviations and pairwise comparisons for age, IQ and the ADHD and RD selection measures for the ADHD, ADHD+RD, RD and normal control groups.

		ADHD+RD *n*=29 (♂=23)		RD *n*=41 (♂=23)		NC *n*=26 (♂=16)		Pairwise Comparisons *p*<.05
Measure	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
Age in Years	(1.31)	9.83	(1.33)	10.10	(1.04)	9.31	(0.92)	NC,A<R
IQ	(15.02)	95.34	(8.64)	104.85	(9.18)	107.32	(9.40)	A+R<R,NC
DBD Parents								
Inattention	(4.50)	17.59	(3.63)	7.22	(4.60)	1.88	(2.12)	A+R,A>R>NC
H/I	(4.60)	18.31	(3.49)	4.22	(3.73)	2.58	(2.08)	A+R,A>R,NC
ODD	(4.67)	8.55	(4.05)	2.83	(2.55)	1.85	(2.24)	A+R,A>R,NC
CD	(2.68)	1.70	(1.79)	0.67	(0.06)	0.10	(0.30)	A>NC,A+R>R,NC
DBD Teacher								
Inattention	(4.91)	17.14	(3.68)	5.43	(4.67)	1.54	(1.90)	A+R,A>R>NC
H/I	(4.99)	17.17	(4.70)	2.80	(3.54)	1.31	(2.31)	A+R,A>R,NC
ODD	(5.11)	7.00	(4.56)	1.42	(2.43)	0.92	(1.69)	A+R,A>R,NC
CD	(2.69)	2.08	(1.88)	0.26	(0.59)	0.04	(0.20)	A+R,A>R,NC
PDISC-IV								
Inattention	(2.16)	16.00	(2.44)	5.02	(3.29)	1.00	(2.20)	A,A+R>R>NC
H/I	(1.92)	15.72	(2.25)	2.24	(2.93)	1.00	(1.98)	A,A+R>R,NC
ODD	(4.96)	4.83	(4.52)	0.49	(1.71)	0.38	(0.98)	A,A+R>R,NC
Reading								
OMT[a]	(10.36)	23.14	(8.95)	25.90	(9.09)	-8.12	(15.09)	R,A+R>A,NC
TRT[a]	(6.50)	22.97	(9.54)	25.51	(9.86)	-1.12	(5.92)	R,A+R>A,NC
PRT[a]	(13.93)	23.97	(11.41)	26.54	(12.00)	-8.62	(18.33)	R,A+R>A,NC

Note. A=Attention Deficit Hyperactivity Disorder, ADHD= Attention Deficit Hyperactivity Disorder, CD= Conduct Disorder, DBD=Disruptive Behaviour Disorders rating scale, H/I=Hyperactivity/Impulsivity, IQ=Intelligence Quotient, NC=Normal Controls, ODD=Oppositional Defiant Disorder, OMT=One Minute Test, PDISC=Parent Diagnostic Interview Scale for Children, PRT=Pseudoword Reading Test, R= Reading Disorder, RD=Reading Disorder, TRT=Text Reading Test.

[a] Mean Delay in Schoolmonths (a negative value indicates advance).

Since successful inhibition occurs in the absence of a response and thus no RT data could be derived, we used RT data of go trials of block 2 to measure IIV in inhibition.

Lexical processing. RT data of a lexical decision making task were used to study IIV in lexical processes, see De Jong et al. for details of this task (2009). In the lexical decision making task, participants had to decide whether words, presented singularly on a computer screen, were valid words or pseudowords (e.g. Meyer & Schvaneveldt, 1971; Milne et al., 2003). Pseudowords were derived from valid words by changing some of the letters with the restriction that the pseudowords were still pronounceable and were consistent with Dutch orthography. All words were monosyllabic. The task consisted of 5 blocks, each containing 25 valid words and 25 pseudowords presented pseudorandomly. In this study, RT data were used for both valid words or pseudowords.

Data processing

For each cognitive domain, 48 trials were analysed corresponding to 3.2 minutes of performance, which corresponded to the duration of a block in the Stop task. The 48 trials for the choice reaction time domain were randomly selected from the first block of the Stop task. The 48 trials for the inhibition domain were the remaining 48 go trials of block 2 of the Stop task after removing the 16 stop trials. For the lexical processing domain, 48 trials were randomly selected from the first 81 trials presented in the lexical decision task, which corresponds to 3.2 minutes.

Incidental missing data and premature responses <150 msec were less than 5% for each domain and were replaced by linear interpolation from the immediately preceding and following RTs (Vaurio et al., 2009). The percentage of data points replaced was 1.7% for two choice processing, 0.9 % for inhibition processing and 2.8% for lexical processing. Groups differed in the number of missing data: during two choice reaction speed, the ADHD group had more missing data than the RD group ($p<.007$) and typically developing children ($p<.04$). During lexical processing, the ADHD+RD group had more missing data than the RD group ($p<.008$) and typically developing children ($p<.02$).

We adopted three analytical methods to obtain a comprehensive overview of IIV. Firstly, we computed the central tendency measures of IIV based on the entire RT distribution (the Gaussian RT distribution). The standard deviation of RT (SD) and the coefficient of variation (Klein et al., 2006), were computed for each cognitive domain.

Secondly, we derived for each participant and for each of the three domains, mu and sigma, using the ex-Gaussian distribution. The ex-Gaussian distribution separates IIV due to the normal (Gaussian) and the positively skewed portions of the distribution assessed by tau, which assesses excessively long RT (Heathcote, Popiel & Mewhort, 1991).

Thirdly, we computed three ISD measures: Overall ISD, Slow ISD and Fast ISD, to study IIV in the entire RT distribution as well as in the isolated slow and fast portions of the RT distribution respectively (Williams et al., 2005). In order to control for group differences in speed, practice and fatigue during the tasks, raw RTs on each trial were purified by partialling out the observed group effect, trial, and group by trial interaction from all RTs for each participant. The remaining residual scores were transformed into T-scores (mean 50, SD 10). ISD measures were obtained for each subject and for each domain by calculating the standard deviation of all T-scores of participants. Following Williams et al. (2005), RTs larger than 3 SDs from the mean were included, since these outliers may indicate lapses in attention. Overall ISD was computed for the entire RT distribution. In addition, two separate ISDs were calculated for 25% of the trials (12 trials) in the slowest portion of the RT distribution (Slow ISD) and for 25% in the fastest portion (Fast ISD) (see supplementary materials for overlap and unique features of the used IIV measures, Appendix D).

Statistical analysis

The speed measures MRT and mu are summarily reported in Appendix E, since neither are measures of variability.

To avoid Type I errors, three omnibus tests (MANOVAs) were conducted for the IIV variables based on the Gaussian RT distribution (SD, coefficient of variation), the ex-Gaussian RT distribution (sigma, tau) and for the ISD variables (Overall ISD, Fast ISD and Slow ISD). The type of IIV measure and the domain were used as within subject factors. The type of measure had two levels for the Gaussian RT measures: SD and coefficient of variation, as did the ex-Gaussian RT measures: sigma and tau. The type of measure had three levels for ISD: Overall ISD, Fast and Slow ISD. Domain had three levels: two choice processing, inhibition and lexical processing. Group was used as between subject factor and had two levels: ADHD (present or absent) and RD (present or absent). Results of the omnibus tests are given in **bold** in the Tables 4.2 and 4.3.

When the omnibus tests were significant, the effects of group, domain and their interaction were further tested for each IIV measure with separate ANOVAs with domain as within subject factor and group as between subject factor. Results of the univariate tests are given in Tables 4.2 and 4.3 (the cells that are *not* in bold).

The two questions posed here were: 1) Is increased IIV specific for ADHD compared to RD and ADHD+RD, and 2) is increased IIV independent of task domain? In order to address the first question, main effects for ADHD and RD and their interaction were inspected for the IIV measures, see Table 4.2. To address the second question, significant ADHD by domain, RD by domain and ADHD by RD by domain interactions were analysed for the IIV measures (see Table 4.3). Significant ADHD by domain, RD by domain and ADHD by RD by domain interactions were further tested with simple contrasts in which IIV during inhibition and lexical processing were compared to two choice processing speed, which was considered as a baseline speed compared to both inhibition and lexical processing.

Due to space limitations, non-significant results, such as ADHD by RD interactions, are not reported in the results but see Tables 4.2 and 4.3.

RESULTS

Is increased IIV specific for ADHD?

Three omnibus tests revealed significant overall main effects for the ADHD and RD factors for the Gaussian RT, ex-Gaussian RT and ISD based IIV measures (see results in bold in Table 4.2). Univariate testing demonstrated significant main effects for both ADHD and RD for the Gaussian RT measures, *SD* and *coefficient of variation* (see the first two rows of Table 4.2). With respect to the ex-Gaussian RT measures, the effects of ADHD and RD were significant for *tau*. A significant RD main effect but no ADHD main effect was noted for *sigma*. ADHD and

RD main effects were noted for *ISD* in the entire RT distribution and in both the slow and fast portions of the RT distribution. These results indicated that ADHD and RD have overlapping IIV impairments. ADHD and RD are not differentiated by the entire RT distribution.

Table 4.2. Multivariate (in bold) and univariate main effects of ADHD and RD, and the ADHD by RD interaction for the three types of IIV measures.

		ADHD		RD		ADHD by RD	
Measure		*F*	η_p^2	*F*	η_p^2	*F*	η_p^2
Gaussian RT distribution		**12.03****	**.09**	**15.74****	**.12**	**2.13**	**.01**
	SD	12.02**	.09	15.73**	.12	2.13	.01
	Coefficient of Variation	20.22**	.15	11.41**	.09	.24	.00
Ex-Gaussian RT distribution		**6.54****	**.05**	**13.24****	**.10**	**4.07**	**.03**
	Sigma	1.57	.01	5.33*	.04	1.14	.01
	Tau	4.52*	.03	7.05**	.06	.95	.00
ISD		**15.93****	**.12**	**8.95****	**.07**	**1.52**	**.01**
	Overall ISD	13.70**	.11	10.72**	.08	2.20	.01
	Slow ISD	14.47**	.11	6.36*	.05	.45	.00
	Fast ISD	10.59**	.09	4.56*	.03	.13	.02

Note. ADHD=Attention Deficit Hyperactivity Disorder; ISD=Intra-Individual Standard Deviation; MRT=Mean Reaction Time; RD=Reading Disorder; SD= Standard Deviation.
* p<.05 ** p<.01.

Is increased IIV independent of domain?

As indicated in bold in Table 4.3, the Gaussian RT measures revealed significant overall interactions for ADHD and RD with domain. Univariate tests showed that both ADHD and RD significantly interacted with domain for *SD,* but not for the *coefficient of variation* (see Table 4.3, results not in bold). Simple contrasts indicated that both ADHD and RD were associated with a larger *SD* during lexical processing compared to two choice processing. No significant differences in *SD* were observed during inhibition versus two choice processing for either ADHD or RD, see Figure 4.1.

Inspection of Table 4.3 indicates that the ex-Gaussian RT measures produced a significant overall RD by domain interaction (see results in bold). Univariate tests indicated that RD but not ADHD interacted significantly with domain for both *sigma* and *tau* (see Table 4.3). Simple contrasts demonstrated that RD was associated with larger *sigma* and *tau* during lexical processing versus two choice processing, but not with larger *sigma* and *tau* during inhibition compared to two choice processing.

These results suggested that increased IIV in RD appears to be a consequence of impaired key processes, whereas increased IIV in ADHD is independent of cognitive domain.

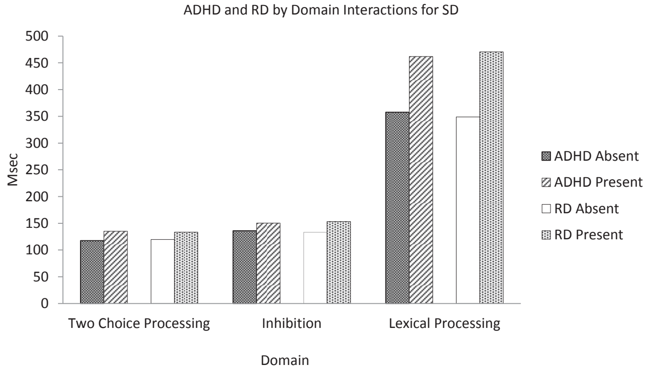

Figure 4.1. The ADHD and RD by domain interactions for SD shows that children with ADHD and children with RD are relatively more variable as assessed with SD during lexical processing compared to two choice processing than children without ADHD and children without RD, respectively.

Table 4.3. Multivariate (in bold) and univariate ADHD and RD and the ADHD by RD by domain interactions for the three types of IIV measures.

	ADHD by Domain		RD by Domain		ADHD by RD by Domain	
Measure	*F*	η_p^2	*F*	η_p^2	*F*	η_p^2
Gaussian RT distribution	**5.95****	**.09**	**3.82***	**.06**	**1.67**	**.02**
SD	7.38**[b]	.06	10.45**[b]	.08	2.14	.01
Coefficient of Variation	1.50	.01	2.49	.02	.27	.00
Ex-Gaussian RT distribution	**2.22**	**.03**	**11.27****	**.17**	**.71**	**.01**
Sigma	1.32	.01	3.98*[b]	.03	.40	.00
Tau	2.04	.01	4.00*[b]	.03	.69	.00
ISD	**1.44**	**.02**	**.28**	**.00**	**1.74**	**.03**

Note. ADHD=Attention Deficit Hyperactivity Disorder; ISD=Intra-Individual Standard Deviation; MRT=Mean Reaction Time; RD=Reading Disorder; SD= Standard Deviation.
[a] significant simple contrast: inhibition versus two choice processing
[b] significant simple contrast: lexical processing versus two choice processing
* *p*<.05 ** *p*<.01.

DISCUSSION

The first focus of this study was to test the specificity of increased IIV in ADHD compared to RD. Increased IIV was not specific for ADHD because it was also observed in RD, which may point to common aetiological factors of ADHD and RD. The combination of ADHD and RD did not differentially impact on IIV for ADHD or RD alone suggesting that the comorbid condition of ADHD and RD is an addition of the two disorders, ADHD and RD. The type of IIV measure had no differential effect for ADHD and RD, except sigma, which was only related to RD, indicating that ADHD and RD cannot be differentiated here by the RT distribution.

Secondly, we examined whether increased IIV was independent of cognitive domain in ADHD and RD. IIV in RD appeared a consequence of impaired key processes, e.g. lexical processing, whereas IIV in ADHD appeared independent of cognitive domain, suggesting IIV impairments in ADHD are more fundamental in origin than in RD.

In our study increased IIV was associated with both ADHD and RD, which agrees with the findings of Borella et al. (2011) who reported increased IIV in children with ADHD and children with RD. Our results are in contrast with those of Williams et al. (2007), who did not found increased IIV in RD. The difference between that report and our findings may be due to differences in the age of participants in the two studies. We included children between 8-12 years, whereas Williams et al. included *adolescents* between 12 to 17 years old. IIV seems to be age dependent and follows an U-shaped developmental curve across the life span: In early childhood IIV is large, small in early adulthood, and large again in late adulthood (Williams et al., 2005). In the present study, children with RD (who were older than children without RD ($F(1,116)=14.06$, $p<.001$, $\eta_p^2=.10$), demonstrated increased IIV compared to children without RD. These results suggest that IIV in RD in our study is not confounded by age and may be a genuine impairment related to RD.

When cognitive domain was taken into account, we found differential effects of ADHD and RD on IIV. Children with RD showed more variable reaction times (as indicated by SD and sigma) and more often showed extreme slow responding (as indicated by tau) during lexical processing, but not during inhibition compared to two choice processing. This supports the idea that IIV in RD is a consequence of a primary impairment in another key cognitive function than IIV. ADHD did not interact with domain except on the IIV measure SD, which suggests that children with ADHD show increased variable responding regardless of type of cognitive domain. Possible origins of IIV in ADHD are inattention (Adams, Roberts, Milich & Fillmore, 2011), a suboptimal state of activation (Castellanos et al., 2005; Sergeant, 2005), or impaired motor control (Klotz, Johnson, Wu, Isaacs & Gilbert, 2012). The nature of IIV in ADHD and RD should be explored in future studies.

We found that IIV is associated with both ADHD and RD along the entire response distribution, since IIV was associated with ADHD and RD regardless of the IIV measure. These findings might indicate that ADHD and RD have impairments in both the fast and slow tail of the RT distribution and the entire RT distribution. It is unclear whether IIV in the fast and the slow tails represent separate processes. Correlations revealed modest associations between tau and ISD-Fast and between ISD-Fast and ISD-Slow, which might indicate that IIV in the fast and slow parts of the RT distribution tap the same process (see supplementary materials for results, Appendix D). In contrast, some IIV variables that are hypothesised to measure IIV in the entire RT distribution showed little overlap: sigma had a weak correlation with the coefficient of variation. This suggests that the IIV measures relate to some extent to a single construct but may also have independent components. This should be taken into account in future studies of IIV, since results with different IIV may not be completely comparable.

Our results should be interpreted in light of some limitations. Firstly, our study groups differed in age, which might have influenced our results. Although matching for age did not alter the results, further studies should include study groups of the same age to exclude possible developmental effects on IIV findings. Secondly, the absence of domain effects during lexical processing in ADHD could have been due to the faster event rate in the lexical decision task than in the Stop task (2.3 s compared to 3 s respectively). Fast event rates are associated with smaller IIV in children with ADHD (see for review, Sonuga-Barke & Castellanos, 2007), whereas in other studies, using fast event rates resulted in decreased IIV in all children (Epstein et al., 2011). Whether cognitive domains in ADHD and RD differentially interact with event rates, is a question for future research.

The current study showed a consistent overlap in increased IIV between ADHD and RD, pointing to common aetiological factors of ADHD and RD. However, there was evidence that IIV varies with cognitive domains between ADHD and RD. IIV in RD seemed to be associated with lexical processing, whereas IIV in ADHD was independent of cognitive domain, suggesting IIV impairments in ADHD are more fundamental in origin than in RD.