CHAPTER 6

Summary and General Discussion

SUMMARY AND GENERAL DISCUSSION

Attention deficit hyperactivity disorder (ADHD) and reading disorder (RD) co-occur more frequently than would be expected by chance (Willcutt & Pennington, 2000). Estimates of the comorbidity of RD in children with ADHD vary between 18 - 45% (Dykman & Ackerman, 1991; Mayes & Calhoun, 2006; Semrud-Clikeman et al., 1992; Wisniewska, Baranowska & Wendorff, 2007). The comorbidity of ADHD in the RD population is estimated at 18-42% (Gayán et al., 2005; Willcutt & Pennington, 2000).

This thesis focused on the overlap and specificity of neurocognitive deficits in ADHD and RD, in an attempt to unravel the origins of the comorbidity between these two disorders. We contrasted ADHD and RD on several domains of neurocognitive functioning, rapid naming and lexical processing, since these neurocognitive functions are presumed to be associated with RD (Denckla, 1973; Bergmann & Wimmer, 2008). In addition, we evaluated other functions that are presumed to be characteristic of ADHD: inhibition process, visuospatial working memory (WM) and intra-individual variability (IIV (Barkley, 1997; Castellanos et al., 2005; Martinussen, Hayden, Hogg-Johnson & Tannock, 2005). Although impairments in these functions have been shown to occur specifically in either ADHD or RD, some reports indicate an overlap in impairments in these functions between these two disorders (Semrud-Clickeman, Guy, Griffin & Hynd, 2000; Willcutt et al., 2005; Williams et al., 2005). Such an overlap in neurocognitive impairments between ADHD and RD might point to common aetiological factors in ADHD and RD. Impairments found specifically in ADHD or RD, on the other hand, would suggest separate aetiological pathways for ADHD and RD. Thus, the main aim of this thesis was to study the specificity and communality of neurocognitive impairments in ADHD and RD.

A second focus was to study whether an effective treatment in ADHD might also be effective in RD or combined ADHD and RD. Possible common aetiological factors in ADHD and RD, as suggested by a possible overlap in neurocognitive impairments in these disorders, may suggest that an effective treatment in ADHD could potentially be effective in RD. Therefore, we studied the effects of a pharmacological treatment for ADHD, namely atomoxetine, on inhibition, visuospatial WM and lexical processing of ADHD and RD.

In this thesis, we found an overlap in a set of neurocognitive impairments for ADHD and RD, which were not previously studied in these two disorders: overlap was found on lexical processing and intra-individual variability (IIV). The former was previously thought to characterise specifically RD and the latter to characterise ADHD (Allor, Fuchs & Mathes, 2001; Castellanos et al., 2005). In addition, we confirmed an overlap between ADHD and RD in rapid naming and inhibition deficits (Semrud-Clickeman et al., 2000; Willcutt, Pennington, Olson, Chhabildas & Hulslander, 2005). ADHD only was characterised by deficits in visuospatial WM, which confirmed earlier findings. Although not the object of study, RD only was characterised

by processing speed impairments. Atomoxetine improved visuospatial WM in children with ADHD+RD but, unexpectedly, it did not ameliorate neurocognitive functioning in the ADHD or RD only groups.

Firstly, we discuss our results on lexical processing and rapid naming, previously presumed to be uniquely impaired in RD. Secondly, using the same study design based on an ADHD group, a RD group, a comorbid ADHD+RD group and a normal control group, we discuss our results on inhibition, visuospatial WM and IIV deficiencies that are considered in the literature as characteristic of ADHD. Thirdly, our findings concerning the effect of atomoxetine on inhibition, visuospatial WM and lexical processing in children with ADHD, RD or ADHD+RD are described. This will be followed by discussion of the implications of our findings and we speculate on future research directions. Thereafter, limitations of this thesis are discussed, and this chapter is closed with a final conclusion.

Results on neurocognitive functions previously presumed to be uniquely associated with RD

Lexical processing. In *Chapters 2* and *3*, we focused on the specificity of deficits in lexical processing in ADHD and RD, which we assumed to be more closely related to reading than phonological processing that was used in previous double dissociation studies as a characteristic variable of RD (Willcutt et al., 2005). The Dual Route Cascaded model has been used to understand lexical processing (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001). Briefly, this model postulates two parallel routes: the lexical route and the sublexical route. In the lexical route, a word that is read is matched to whole word representations in the mental orthographic lexicon, which contributes to efficient and fast reading. The sublexical route uses rules for grapheme-to-phoneme conversion, thus words are read letter by letter. Both routes have access to the phonological lexicon.

Although impairments in lexical processing are presumed to be characteristic of RD, there is evidence for overlap in lexical processing deficits between ADHD and RD. Lexical *route* processing taps orthographical knowledge, which is impaired in RD (Bergmann & Wimmer, 2008) and in ADHD (Willcutt et al., 2005). We hypothesised, therefore, that impairments in accuracy of lexical route processing might overlap between ADHD and RD, which we confirmed in *Chapters 2* and *3*. Unexpectedly, not only impairments in accuracy in lexical route processing were found in RD, but RD was also associated with slower lexical route processing (*Chapters 2 and 3*).

In contrast, sublexical route processing taps phonological processing, which has been shown to be accurate but very slow in individuals with RD in languages with a regular orthography such as Dutch and German (Bergmann & Wimmer, 2008). Unexpectedly, we found accuracy deficits in sublexical route processing in *both* RD and ADHD (*Chapter 2*). We confirmed slower sublexical route processing in children with RD compared to children without RD (*Chapters 2* and *3*).

Our findings may reflect a genuine overlap in accuracy of lexical processes between ADHD and RD. However, speed-accuracy trade-off effects could also have contributed in the present findings in ADHD. The speed-accuracy trade-off refers to the normal phenomenon that speeding up reaction time increases the number of errors, whereas increasing accuracy leads to slower processing. Mulder et al. (2011) demonstrated that children with ADHD had a less optimal speed-accuracy trade-off than children without ADHD with a preference for speed over accuracy. It may be possible that children with ADHD in our studies made more errors in order to gain speed on the lexical processing tasks. Findings on the two lexical processing tasks described in *Chapter 2* are consistent with this hypothesis, since children with ADHD were less accurate but not slower on these tasks than children without ADHD. However, children with ADHD were both slower and more inaccurate on the lexical processing task described in *Chapter 3* arguing against a major role of speed-accuracy trade-off effects in our findings.

The unexpected finding that both ADHD and RD were associated with inaccurate sublexical route processing might indicate that accuracy of sublexical route processing is implicated more in RD in languages with a consistent orthography than previously suggested. However, lexical processing might have played a role in the impaired sublexical route processing. Some children reported that they did not read letter by letter but instead read clusters of letters, suggesting they used a rather lexical route processing strategy while reading pseudohomophones and non-words. The children that were included were not beginning readers but had received 4 or more years of reading instructions. Possibly, sublexical route processing is more relied upon in the early stages of the learning to read process. In the more advanced stages, children are trained to rely more on lexical route processing to gain speed than on sublexical route processing, even with pseudohomophones or non-words. Whether accuracy of sublexical route processing is associated with RD and ADHD in languages with a consistent orthography should be object of further study.

Rapid naming and processing speed. In *Chapter 2* we tested the specificity of rapid naming impairments between ADHD and RD. Rapid naming impairments are thought to be characteristic of RD (Denckla, 1973). However, there is evidence of rapid naming impairments in ADHD as well (Tannock, Martinussen & Frijters, 2000; Semrud-Clickeman et al., 2000). Thus, we predicted an overlap in rapid naming impairments between ADHD and RD, which we confirmed in *Chapter 2*.

Interestingly, we found that RD but not ADHD was associated with slow performance on other speed measures than rapid naming, namely, mean reaction time (MRT) on both the lexical processing task and the Stop task. This finding suggests that rapid naming taps another speed process than MRT. This is in line with findings of Shanahan et al. (2006) who demonstrated that MRT on a Continuous Performance task and the Stop task did not relate to a composite measure of processing speed. This composite measure was based on rapid

naming, the Coding subtest of the Wechsler Intelligence Scale for Children (WISC), and speed of processing of the Stroop task. Both ADHD and RD were associated with impairments in this composite measure of processing speed (Willcutt et al., 2005). These findings suggest that ADHD may have speed impairments on tests tapping *automatized* speed of processing, as assessed by rapid naming and WISC Coding. RD, in contrast, may be characterised by a more general impairment in speed of processing, thus both *automatized* and *non-automatized* processing. The non-automatized speed was assessed here by the MRT on choice reaction time tasks, such as the Stop and lexical processing tasks.

Results on neurocognitive functions previously presumed to be uniquely associated with ADHD

Inhibition. We hypothesised in *Chapter 3* that there would be an overlap in impairments in inhibition between the ADHD and RD groups (Willcutt et al., 2005). Contrary to prediction, impairments in inhibition were especially found in RD and to a lesser extent in ADHD (*Chapter 3*). Our results contrast with findings in a recent meta-analysis on inhibition in ADHD and other psychiatric or developmental disorders (Lipszyc & Schachar, 2010). This meta-analysis suggests that inhibition impairments are especially associated with comorbid ADHD+RD, since larger effect sizes for inhibition impairments were demonstrated in children with combined ADHD+RD (g=.82, larger effect size) than in children with only ADHD (g=.62, medium effect size) or only RD (g=.36, small effect size). However, the number of studies for the combined ADHD+RD group and RD only were small: n=4 and n=6 respectively, whereas a large number of studies (n=68) included children with ADHD only. It is possible that the medium effect size for inhibition impairments found in the ADHD only group may have been inflated by unscreened reading deficits. Some of the presumed ADHD only groups in the studies in the meta-analysis may have included children with comorbid ADHD+RD, since many studies that included an ADHD only group did not explicitly screen for RD (e.g. de Zeeuw et., 2008; Klein et al., 2006; Lijffijt, Kenemans, Verbaten & Van Engeland, 2005; Pliszka, Liotti & Woldorff, 2000). Given the degree of comorbidity between ADHD and RD, it seems likely that the hypothesised ADHD only group effect in the meta-analysis also held for children with comorbid RD. Another possible reason for an inflated effect size for inhibition impairments in ADHD may be publication bias, although the reported publication bias was relatively small (Lypszyc & Schachar, 2010). Thus, the available data suggest that inhibition impairments may be less uniquely associated with ADHD than previously suggested (Barkley, 1997).

Visuospatial working memory. In *Chapter 3*, we hypothesised that ADHD but not RD or the combination of ADHD with RD would be associated with visuospatial WM impairments (Martinussen et al. 2005). As predicted, children with ADHD only were characterised by visuospatial WM impairments (*Chapter 3*). Our findings support the study of Martinussen et al. (2005) on visuospatial WM impairments in ADHD only. These researchers compared visuospatial WM abilities to phonological WM abilities in children with ADHD, ADHD+RD and

children with RD. Phonological WM is responsible for the storage and rehearsal of verbal material, whereas visuospatial WM involves the storage and rehearsal of nonverbal and spatial information. Martinussen et al. found larger effect sizes for visuospatial storage deficits in ADHD after partialing out reading deficits, whereas this was not found for phonological WM. This finding may indicate that visuospatial WM impairments are uniquely associated with ADHD, whereas phonological WM deficits are associated with both ADHD and RD.

Studying WM in ADHD is relevant, since WM impairments may have a functional relationship to attentional processing in ADHD (Kofler, Rapport, Bolden, Sarver & Raiker, 2010). However, not only visuospatial WM but also phonological WM seems to be related to attention in ADHD; Kofler et al. (2010) showed that increased cognitive load for both visuospatial and phonological WM increased inattentive behaviour in children with ADHD. In addition, it was shown that placing demands on the central executive processing part of WM increased inattentive behaviour. The central executive processing part of WM is an attentional control mechanism responsible for oversight and coordination of the subsidiary phonological and visuospatial WM systems. Unfortunately, in the study by Kofler et al. (2010) no ADHD+RD or RD groups were included. Thus, it could not be tested whether the relationship between WM impairments and attention deficits was distinct in comorbid ADHD+RD and ADHD only. Inclusion of an RD group would help to clarify whether phonological WM impairments in RD might account for the subtle attention deficits found in children with RD (Willcutt et al., 2005).

Intra-individual variability (IIV). Available published data indicate increased IIV to be a characteristic of ADHD (Castellanos et al., 2005; Klein, Wendling, Huettner, Ruder & Peper, 2006). However, the only study that examined IIV in both ADHD and RD found IIV impairments in both ADHD and RD (Williams et al., 2005). We predicted, therefore, overlap in increased IIV between ADHD and RD, which we confirmed in *Chapter 4*. We tested whether IIV was dependent on impaired key processes in ADHD and RD, namely, lexical processing and inhibition, respectively. IIV in RD was partly dependent on impaired lexical processing, whereas IIV in ADHD was independent of impaired key processes, which suggests that increased IIV in ADHD is a more fundamental feature than in RD.

However, IIV may not be exclusively impaired in ADHD or RD; increased IIV has also been observed in other psychiatric disorders: schizophrenia, depression (Kaiser et al., 2008), and autism (Geurts et al., 2007). Possibly, IIV is a consequence of impaired key processes in all these disorders. For example, in depression, a negative mood results in increased attention deficits, which may lead to increased IIV. IIV in these clinical conditions may be a consequence of task demands. This, however, has never been tested. Our study on IIV in ADHD and RD suggests that IIV is more a suitable variable in identifying ADHD than RD, since increased IIV seems more characteristic for ADHD than RD.

Atomoxetine

Chapter 5 investigated the effects of atomoxetine on inhibition, visuospatial WM and lexical processing in ADHD, ADHD+RD and RD. Since earlier pharmacological studies showed a positive effect of atomoxetine on inhibition in adults with ADHD (Chamberlain et al., 2007), we expected beneficial effects of atomoxetine on inhibition in children with ADHD. In addition, possible common aetiological factors in ADHD and RD, as indicated by an overlap in neurocognitive impairments between these disorders suggest that an effective treatment in ADHD may be potentially effective in RD. It was hypothesised that atomoxetine would not only improve inhibition but also visuospatial WM and lexical processing in RD. Interestingly, we found that atomoxetine had a differential effect in the comorbid ADHD+RD group compared to the ADHD and RD-only groups: Atomoxetine improved visuospatial WM and to a lesser extent inhibition in children with both ADHD+RD. Atomoxetine, however, showed no effect on inhibition in the ADHD or RD-only groups nor on visuospatial WM or lexical processing.

Our findings are confirmed by another study that tested the effects of atomoxetine on WM in children with ADHD or ADHD+RD: atomoxetine improved visuospatial WM in the ADHD+RD group but showed no effect in the ADHD-only group (Sumner et al., 2009). A possible explanation for the differential effects of atomoxetine in ADHD and ADHD+RD may be a difference in noradrenaline levels in these two groups (Halperin et al., 1997). Children with ADHD+RD have been reported to have higher plasma levels of the noradrenaline metabolite 3-methoxy-4-hydroxyphenylglycol (MHPG) than children with ADHD (Halperin et al., 1997). MPHG appears to be inversely associated with academic achievement and verbal processing but was not related to behavioral ratings or measures of attention and impulsivity (Halperin et al., 1997). Although the findings of Halperin et al. (1997) suggest that noradrenaline has no relationship with inhibition, recent studies implicate noradrenergic neurotransmission in modulating inhibition (Pattij, Schetters, Schoffelmeer & Van Gaalen, 2012). Noradrenergic neurotransmission (and dopaminergic neurotransmission) seems also to be involved in visuospatial WM, since Gamo, Wang and Arnsten (2010) showed improved visuospatial WM in rats after taking atomoxetine, which stimulated indirectly the α_2 adrenoceptor and D_1 dopamine receptors in the prefrontal cortex. Possibly, ADHD and ADHD+RD differ in the availability or sensitivity of adrenoceptors and D_1 dopamine receptor needed for inhibition and visuospatial WM, which should be a focus of further study. This could possibly also help resolve the issue why atomoxetine leads to greater improvements of visuospatial WM than inhibition.

Other studies on the effects of atomoxetine in children with ADHD, in contrast, found positive effects on executive functions such as inhibition and visuospatial WM, possibly because in these studies treatment was of longer duration than the four weeks as in the current study. Gau and Shang (2011) found improved inhibition and spatial WM after 12 weeks of open label treatment with atomoxetine but the onset of the beneficial effects of atomoxetine differed for inhibition and spatial WM. Atomoxetine ameliorated inhibition after

4 weeks of treatment, whereas the effects on spatial WM were seen only after 12 weeks of treatment. Wehmeier et al. (2011) showed beneficial effects of atomoxetine compared to placebo on inhibition in children with ADHD after 8 weeks of treatment. Positive effects of atomoxetine were also found after 6 months of treatment on selective attention, attentional control and self-reports of executive functioning in children with ADHD compared to matched controls (Maziade et al., 2009).

Although our relatively short treatment duration might explain the absence of any effects of atomoxetine on the used neurocognitive functions in the ADHD and RD only groups, improvement by atomoxetine on executive functioning reported in other studies might be due to placebo effects. These studies did not incorporate a placebo condition (Gau & Shang, 2011; Maziade et al., 2009) or a normal control group to exclude learning effects (Gau & Shang, 2011; Wehmeier et al., 2011). In addition, participating children were not screened for reading impairments.

Implications of the present findings for the origins of the comorbidity of ADHD and RD

As detailed in the Introduction, three behavioural-genetic hypotheses on the origins of the comorbidity between ADHD and RD have been suggested in the literature by using a double dissociation design: the *phenocopy hypothesis*, the *cognitive subtype hypothesis* and the *common aetiology hypothesis*. These hypotheses searched for a single characterising impairment for each disorder. Although we did not find a single deficit that characterises the comorbidity between ADHD and RD, the three behavioural-genetic hypotheses might still be applicable. We found no evidence for the *phenocopy hypothesis*: the comorbid group did not show the neurocognitive deficits of either ADHD or RD. There might be evidence for a distinct aetiological pathway of the combination ADHD+RD, compatible with the *cognitive subtype* hypothesis: Pharmacological treatment with atomoxetine was found effective in enhancing visuospatial WM and inhibition only in comorbid ADHD+RD. However, the current findings point prominently towards the *common aetiology hypothesis,* although we did not find a single common deficit but various common deficits. Our findings are in accordance with the multiple deficit model that states that the comorbidity between heterogeneous developmental disorders such as ADHD and RD is based on shared aetiological and neurocognitive risk factors (Pennington, 2006).

The origins of the comorbidity between ADHD and RD may be complex. ADHD and RD may overlap considerably at the aetiological level, besides some non-shared aetiological factors that may lead to either ADHD or RD alone or the combination ADHD+RD.

Future directions

Our findings underline the importance of comparing ADHD to RD, since neurocognitive impairments that were supposed to characterise ADHD overlap with RD, such as impairments in inhibition and IIV. Also, impairments that were thought to be unique to RD overlap with

ADHD, such as impairments in rapid naming and lexical processing. Future studies should include an ADHD, ADHD+RD and an RD group to provide a definitive answer to the issue whether the here tested neurocognitive functions are associated with ADHD, RD or the combination of these disorders. Including these four groups might also be important in studying the effects of (pharmacological) treatments in ADHD and RD, since comorbid RD in ADHD differentiated the effects of atomoxetine. Future research could focus on the overlap in the neurocognitive functions tested here between ADHD and other disorders than RD. For example, there is evidence that increased IIV impairments occurs in various psychiatric disorders such as depression, schizophrenia, autism (Geurts et al., 2007; Kaiser et al., 2008).

When the overlap and specificity of the neurocognitive functions tested here between ADHD and RD is confirmed, these neurocognitive functions may be used as endophenotypes in the search for the genetic underpinnings of the comorbidity of ADHD and RD. Endophenotypes are thought to mediate the relationship between a genetic predisposition of a disorder (genotype) and disease symptoms of the same disorder (phenotype) (Gottesman & Gould, 2003). Endophenotypes may be useful when the genotype and phenotype are heterogeneous in nature since they may create more homogeneous subgroups of patients based on shared endophenotypic dysfunction (Almasy & Blangero, 2001). Both ADHD and RD are heterogeneous in symptomatology, as well as in their genetic underpinnings, which makes it difficult to identify susceptible genes for ADHD, RD and their comorbidity. Endophenotypes may therefore be more useful in exploring different pathways leading to a disorder, than clinical phenotypes (Waldman, 2005). Thus, using endophenotypes in the search for the genetic underpinnings of the symptoms of the comorbidity between ADHD and RD might result in a smaller number of target genes than focusing on the genetic underpinnings of the clinical symptoms.

Clinical Implications

The results of this thesis illustrate for the clinician that ADHD and RD are more alike than different. However, the two disorders are often diagnosed and treated in different settings: child psychiatry and remediation practices. This thesis shows that screening for the comorbidity between ADHD and RD is important, since the comorbidity exists not only at the phenotypic or clinical level but also at the neurocognitive level, which may point to shared aetiological pathways underlying ADHD and RD. If characteristic neurocognitive profiles in ADHD, RD or the combined disorders can be identified, such profiles might yield new clues concerning the aetiology of these disorders. Increasing knowledge of the aetiology of ADHD and RD and their comorbidity will then hopefully lead to more reliable methods of diagnosis and better treatments of ADHD and RD. In the future, neurocognitive measures could be used for diagnostic purposes in the comorbidity between ADHD and RD, since the neurocognitive profile is supposed at a more aetiological level than the clinical diagnoses of ADHD and RD.

The clinical diagnoses ADHD and RD could be combined with the "neurocognitive diagnoses" to subtype ADHD, RD and their comorbidity which may be useful to predict treatment effects. For example, shared inhibition deficits in ADHD, RD and ADHD+RD may predict that treatment A is effective in ADHD, RD and ADHD+RD, whereas working memory deficits in ADHD+RD may indicate that treatment B is effective in ADHD+RD. We hope that in the future, if more knowledge of neurocognitive profiles of ADHD, RD and their comorbidity is gained, this will aid clinicians to tailor treatment to the specific needs of an individual child.

Limitations of the current study

Some limitations of the presented studies are worth noting. Firstly, the number of participants in each group was limited. In small sample sizes, the influence of extreme or atypical cases is greater than in larger samples. In order to address this issue, we analysed the data of the four groups using a factorial design using two factors: ADHD (absent vs present) and RD (absent vs present) which enhanced power of the analyses. We measured large effect sizes (partial eta squared) for the RD factor, convincingly indicating that despite limited sample size, RD was strongly associated with poor inhibition, enlarged IIV, poor rapid naming, poor lexical processing and speed impairments. ADHD was also associated with these impairments, but the associations were less strong. Further research could show whether the small to medium effect sizes for these neurocognitive functions in ADHD are valid or might have been due to the small size of the ADHD group.

Secondly, we included relatively few neurocognitive tasks. We could therefore only study the overlap and specificity of a limited range of neurocognitive functions in ADHD and RD, which limits the generalization of our findings. For executive functioning, we used measures of inhibition and visuospatial WM. Although visuospatial WM is more related to ADHD than verbal WM, verbal WM tasks may be used in further studies to investigate whether ADHD and RD may be differentiated on visuospatial and verbal WM (Martinussen et al., 2005; Roodenrys, Koloski & Grainger, 2001). In addition, the central executive aspect of WM is especially impaired in ADHD (Martinussen et al., 2005) and, therefore, the effects of atomoxetine on this aspect of WM may be worth studying in ADHD. Further, timing mechanisms may be worth studying in combination with rapid naming in both ADHD and RD. Impairments in timing mechanisms are found in both ADHD and RD (Toplak, Rucklidge, Hetherington, John & Tannock, 2003; Tiffin-Richards, Hasselhorn, Richards, Banaschewski & Rothenbreger, 2004). Impairments in timing mechanisms and rapid naming may be a reflection of cerebellar dysfunction, which is found in both ADHD and RD (Bledsoe, Semrud-Clikeman & Pliszka, 2009; Nicholson, Fawcett & Dean, 2001). We included only one type of language measure in our studies, lexical processing, which may have limited our conclusions on impaired key processes in RD. Future studies should include multiple reading tasks and phonological tasks.

Thirdly, conclusions on the possible origins of the comorbidity between ADHD and RD were based on a single measurement in time in *Chapter 2, 3* and *4*. Future work should assess whether the neurocognitive profiles of ADHD, RD and comorbid ADHD+RD that were found are stable over time in longitudinal studies.

Final Conclusion

ADHD and RD share neurocognitive impairments in lexical processing, rapid naming and IIV. These findings may point to common aetiological pathways for ADHD and RD. Visuospatial WM impairments were found in ADHD only, whereas RD was characterised by slower MRT, which suggests separate origins for ADHD and RD. Atomoxetine had beneficial effects on visuospatial WM and to a lesser extent on inhibition in children with ADHD+RD. The findings from the atomoxetine study suggest that distinguishing the single ADHD and RD groups from the comorbid ADHD+RD group might be important for treatment purposes since the ADHD+RD reacts differently to treatment than the single diagnosis groups.

We may conclude that ADHD and RD, two disorders that are clinically very different, are more alike than different at a neurocognitive level and possible also at a more aetiological level.