

# **Internalizing, Externalizing and Attention Problems Among Learning Disability Subgroups**

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Master's Thesis

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Comorbidity between LDs and socio-emotional problems is well known, but very little is known about the LD subtype differences concerning the co-occurring socio-emotional problems. Additionally, especially the knowledge about the comorbid LD subtype, which is a combination of both reading (RD) and mathematical disabilities (MD), is scarce. In the current study, three LD subtypes (RD, MD and RD+MD) were compared in the co-occurrence of mother reported socio-emotional problems using a sample of 618 children from a Finnish clinical data-base. Also, gender differences and interaction of LD subtype and gender were analyzed. Analyses conducted with Multivariate Analysis of Variance and Analysis of Variance revealed that children with MD ( $n = 161$ ) had more overall and internalizing socio-emotional problems than children with RD ( $n = 277$ ) and RD+MD ( $n = 180$ ), as well as more anxious/depressed and attention problems than children with RD. Main effect for gender indicated that boys overall had more rule-breaking behavior than girls. Also, an interaction effect between LD subtype and gender was detected, indicating that boys in the MD group had more externalizing problems than boys in the RD group. Cross-tabulation and  $\chi^2$ -test revealed that there were more boys than expected in the MD group, and less boys than expected in the RD group who had severe (close to clinical range or clinical range) attention and anxious/depressed problems. In the subset of girls, more girls than expected in the RD group and less girls than expected in the MD and RD+MD groups had severe aggressive behavior or rule-breaking behavior. The results suggested that children with MD, and especially boys with MD, might be at risk having more comorbid socio-emotional problems than the individuals in the other subgroups, and that MD boys might have also more severe socio-emotional problems than boys in the other subgroups. Further research is needed to understand the reasons for the found LD subtype differences in co-occurring socio-emotional problems. Overall, knowing and understanding the possible LD subtype differences in comorbid socio-emotional problems is important to identify the problems as early as possible, and to observe more carefully those children who might be at more risk developing or having comorbid problems.

*Keywords:* learning disabilities, reading disability, comorbidity, comorbid learning disability, socio-emotional problems, childhood, gender differences

# JYVÄSKYLÄN YLIOPISTO

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Kehityksellisten oppimisvaikeuksien ja sosioemotionaalisten ongelmien yhtäaikainen esiintyminen (komorbiditeetti) on ollut jo pitkään tiedossa. Tutkimustietoa mahdollisista eri oppimisvaikeusryhmien välisistä eroista sosioemotionaalissa oireilussa on kuitenkin vain vähän. Lisäksi tietämys matematiikan (MV) ja lukemisen vaikeuksien (LV) komorbiditeetin yhteyksistä sosioemotionaalisiin ongelmiin on niukkaa. Tässä tutkimuksessa verrattiin LV- ( $n = 277$ ) ja MV- ( $n = 161$ ) sekä komorbidiryhmää ( $n = 180$ ) samanaikaisesti esiintyvien sosioemotionaalisten ongelmien esiintymisessä äitien raportoimana. Lisäksi tutkittiin sukupuolieroja sekä sukupuolen ja oppimisvaikeusryhmittelyn yhdysvaikutusta. Tutkimuksen otos perustuu Suomalaiseen kliiniseen aineistoon, josta tutkimukseen valikoitui 618 lasta. Varianssianalyysien tulokset paljastivat, että MV-ryhmässä esiintyi enemmän sosioemotionaalista kokonaisuireilua sekä sisäänpäin suuntautuvaa sosioemotionaalista oireilua kuin LV- ja komorbidiryhmässä, ja enemmän ahdistuneisuus ja masentuneisuus oireilua sekä tarkkaavuuden ongelmia kuin LV-ryhmässä. Sukupuolella havaittiin olevan päävaikutus sääntöjä rikkovan oireilun osalta siten, että pojilla esiintyi oireilua enemmän kuin tytöillä. Lisäksi sukupuolella ja oppimisvaikeusryhmittelyllä havaittiin olevan yhdysvaikutusta ulospäinsuuntautuvaan oireiluun siten, että MV- ryhmän pojilla näyttäytyi enemmän oireilua kuin muiden oppimisvaikeusalaryhmien pojilla. Ristiintaulukointi ja  $\chi^2$ -testaus paljasti, että odotettua useammalla pojalla MV-ryhmässä ja odotettua pienemmällä osalla pojista LV-ryhmässä oli huomattavia (lähellä kliinistä tasoa tai kliinisen tason) tarkkaavuuden sekä ahdistuneisuuden ja masentuneisuuden oireita. Tyttöjen osalta odotettua useammalla tytöllä LV-ryhmässä ja odotettua pienemmällä osalla MV- ja komorbidiryhmässä oli huomattavaa sääntöjä rikkovaa tai aggressiivista käyttäytymistä. Tulokset viittaavat siihen, että lapset, joilla on MV, erityisesti pojat, vaikuttaisivat olevan riskiryhmässä samanaikaiselle sosioemotionaalille oireilulle. Lisäksi pojilla, joilla on MV vaikuttaisi olevan myös vakavampaa sosioemotionaalista oireilua kuin pojilla muissa oppimisvaikeusalaryhmissä. Jatkossa tulisi selvittää syitä löytyneille oppimisvaikeusryhmäeroille. Tutkimusalue on tärkeä, sillä mahdollisten oppimisvaikeusalaryhmien välisten eroavaisuuksien tunteminen ja niiden ymmärtäminen samanaikaisesti esiintyvän sosioemotionaalisen oireilun osalta mahdollistaa niiden oppilaiden paremman tunnistamisen, joilla ongelmat tyypillisesti kasaantuvat. Mahdollisimman aikaisella puuttumisella ja oikein suunnatuilla tukitoimilla voidaan parhaiten pyrkiä ehkäisemään ongelmien kasaantumista.

*Avainsanat:* kehitykselliset oppimisvaikeudet, lukemisvaikeus, matemaattiset oppimisvaikeudet, komorbiditeetti, komorbidi oppimisvaikeus, sosioemotionaaliset ongelmat, lapsuus, sukupuolierot

## INTRODUCTION

The terminology concerning learning problems varies based on the set criteria. According to Pennington (2009), the term learning *disorder* refers to any neurodevelopmental disorder that interferes with learning skills and is a broader term than learning *disability* (LD). LDs such as reading disability (RD) and math disability (MD) represent a subset of learning disorders (Pennington, 2009), and are referred also as dyslexia and dyscalculia (Learning Disabilities Association of America, 2017). The problems underlying LDs are neurologically-based and can impair basic learning skills such as reading, writing, speaking, and calculating numbers (National Institute of Child Health and Human Development, 2016). There can be impairment also in higher level skills, such as memory, attention, abstract reasoning, organization or time planning (Learning Disabilities Association of America, 2017). LD is often discovered after school beginning due to the difficulties in one or more subjects (National Institute of Child Health and Human Development, 2016). In the fifth edition of Diagnostic and Statistical Manual of Mental Disorders (DSM-5, APA, 2013) the impairment in reading, mathematics and written expression are classified as Specific Learning Disorders (SLD) providing the alignments for diagnostic purposes. In Finland, the diagnostic classification in use is the ICD-10, International Classification of Diseases, which also specifies these three learning disability subtypes (National Institute of Health and Welfare, 2011). In this study the terms used are MD, RD, and RD+MD, last referring to the comorbid LD subtype.

According to the American Psychiatric Association (APA, 2013), specific learning disorders are common conditions affecting around 5-15 % of school-age children across different languages. Overall, the prevalence rates vary widely depending on the definitional criteria (Landerl, Fussenegger, Moll & Willburger, 2009). For a long time, most of the LD research has focused on RD (see Barbaresi, Katusic, Colligan, Weaver & Jacobsen, 2005), while the subtypes of MD (see Mazzocco & Myers, 2003) and especially the comorbid type RD+MD (see Dirks, Spyer, van Lieshout, & Sonnevile, 2008) have been far less studied. During recent years the research interest towards MD and the comorbid type RD+MD have increased (Barbaresi et al., 2005; Dirks et al., 2008; Landerl, et al., 2009; Landerl & Moll, 2010; Moll, Göbel & Snowling, 2015; Moll, Kunze, Neuhoff, Bruder & Schulte-Körne, 2014; Willcutt et al., 2013). As Willcutt et al. (2013) have stated, it is hard to make interpretations about the prevalence share of each LD subgroup because the estimates of RD and MD co-occurrence among the individuals with either disability is wide-ranging. Landerl and Moll (2010) have summed up that comorbidity rates in

population-based samples vary from 11 to 70% among children with either disability. More recent studies have shown a comorbidity rate of about 50% (Koponen et al., 2018; Moll et al., 2014).

Despite the increased research interest towards co-occurrence of RD and MD, the understanding of it is inconsistent and scarce (see Landerl & Moll, 2010). It seems that individuals with weaknesses in both domains (RD+MD) experience greater problems among math and reading compared to the individuals with problems among single domain (Dirks et al., 2008; Willcutt et al., 2013). The possible causes of comorbidity between distinct diagnoses are complex. In terms of comorbidity of LD subtypes, the correlated liabilities model, explaining the comorbidity of RD and MD, has gained support from the relatively recent twin studies (Kovas et al., 2007; Willcutt et al., 2013). The model suggests that RD and MD often co-occur because of shared liability, however there are also additional influences that are specific to each condition and that produce the occurrence of isolated conditions (Pennington, Willcutt & Rhee, 2005; Willcutt et al., 2013).

Besides the common co-occurrence of RD and MD, LDs are also associated to other neurodevelopmental and socio-emotional problems, such as ADHD (e.g. Mayes, Calhoun & Crowell, 2000), anxiety (e.g. Nelson & Harwood, 2011b), and depression (e.g. Heath, & Ross, 2000; Maag & Reid 2006; Nelson & Harwood, 2011a). Panicker and Chelliah (2016) have found associations between LD and lack of psychological resilience. As Pennington et al. (2005) have concluded, comorbidity of mental disorders generally is common among both adults and children. One way of defining socio-emotional problems is to divide them in to internalizing and externalizing problems (Achenbach & Edelbrock, 1978). The first one is referring to emotional problems such as depression, anxiety and somatization, while the second one refers to behavioral problems such as aggressiveness and delinquent behavior (Achenbach & Rescorla, 2001). Despite these problems have been found to frequently co-occur (Pesenti-Gritti et al., 2007), this dichotomy is often used in studies researching the socio-emotional problems in children (e.g. Rescorla et al., 2007), and has long been used also in association to LD studies (e.g. Prior, Smart, Sanson, & Oberklaid, 1999).

Among the different LD subtypes, there is more research regarding the co-occurrence of RD and socio-emotional problems than MD or RD+MD and parallel comorbid problems. Nevertheless, some support of co-occurring internalizing and externalizing problems for each LD subtype exists (e.g. Willcutt et al., 2013). However, there are very few studies that include all these subgroups (RD, MD and RD+MD). Thus, more knowledge is needed on the social-emotional problems among children with MD or RD+MD, as well as from the possible LD subgroups differences on co-occurring socio-emotional

problems, which are the main interests in the current study. First, the previous findings concerning the socio-emotional problems of each subtype will be summarized. Second, the lacking knowledge of the LD subtype differences on this matter will be introduced.

Children with RD have been reported having more overall internalizing problems (Willcutt et al., 2013), anxiety (Arnold et al., 2005; Goldston et al., 2007; Mammarella et al., 2016; Willcutt & Pennington, 2000b), depression (Arnold et al., 2005; Mammarella et al., 2016; Willcutt & Pennington, 2000b), somatic complaints (Arnold et al., 2005; Willcutt & Pennington, 2000b), and withdrawal (Willcutt & Pennington, 2000b) than controls. Also, RD is associated to higher levels of overall externalizing behavior (Willcutt et al., 2013), aggressive behavior (Willcutt & Pennington, 2000b), and delinquent behavior (Arnold et al., 2005; Willcutt & Pennington, 2000b) than controls. ADHD or symptoms of ADHD, especially inattention, has been found to be associated with RD (Willcutt & Pennington, 2000a; Willcutt & Pennington, 2000b; Willcutt et al., 2013).

Similarly, children with MD have been found to have more internalizing problems than controls (Willcutt et al., 2013). Domain-specific anxiety has been studied specifically in association with math ability: in addition to findings that math anxiety has been found to be negatively associated with math skills (Sorvo et al., 2017), even after controlling for trait anxiety (Ashcraft & Kirk, 2001), children in MD group and low achieving group have been found to have more domain specific anxiety than the typically developing children (Wu, Willcutt, Escovar & Menon, 2014). Moreover, children with MD have also been reported to have more externalizing problems (Willcutt et al., 2013), ADHD (especially inattentive type) or attention problems (Willcutt et al., 2013; Wu et al., 2014), and social problems (Wu et al., 2014) than controls. Auerbach, Gross-Tsur, Manor and Shalev (2008) found, though with small effect sizes, that more youths with persistent dyscalculia had externalizing problems and attention problems than the youths in non-persistent dyscalculia group at the age of 16-17, bringing forward the significance of the persistence of MD in association to these comorbid problems.

In terms of the comorbid subtype RD+MD, Willcutt et al. (2013) found that in addition to the other subgroups the comorbid group had more internalizing and externalizing problems, and more symptoms of ADHD (especially inattentive type) than the controls. Martinez and Semrud-Clikeman (2004) found that only the RD+MD group had significantly more emotional symptoms, such as depression, compared to the controls, while the relationship with single LDs and these symptoms compared to controls remained non-significant. To best of my knowledge, Willcutt et al.'s (2013) and Martinez and Semrud-Clikeman's (2004) studies are also the few researches that have compared the

three LD subtypes in the co-occurrence of socio-emotional problems. Willcutt et al. (2013) reported that RD+MD group had more internalizing problems and inattentive problems than the groups with single deficit. No differences between the RD and MD groups were found. However, Martinez & Semrud-Clikeman (2004) study indicated no significant differences at all between these three LD subtypes.

Altogether, there seems to be consistent evidence that children in all the three LD subtypes (RD, MD and RD+MD) show more comorbid internalizing problems than the controls. Similarly, comorbid externalizing problems are found in relation to each subtype, but it is noteworthy that the associations between LD subtypes and especially externalizing problems might be mediated by ADHD or ADHD symptoms: in Willcutt and Pennington's (2000b) study the association between RD and externalizing problems did not remain significant after controlling for relation between RD and ADHD. This finding is supported also by Willcutt et al.'s (2013) study where it was found that comorbidity between the LD subgroups and externalizing psychiatric disorders was restricted to those subjects who also met the criteria for ADHD. Furthermore, not only there are less studies concerning MD and co-occurring socio-emotional problems than RD and corresponding problems, the research designs (e.g. diagnostic criteria and groups included) in the studies concerning MD seem to vary in greater extent than in the studies concerning RD. The most of uncertainty is associated with the LD subgroup differences in the prevalence of socio-emotional problems, as the two previous studies conducted on this area (Martinez & Semrud-Clikeman, 2004; Willcutt et al., 2013) have inconsistency in their findings (see previous paragraph). This might be related to considerable difference in the sample sizes, as Willcutt's et al. (2013) study had a sample size of 1023, and Martinez & Semrud-Clikeman's (2004) study not showing significant LD subgroup differences included only 120 participants. Accordingly, more research is needed on this area.

Additionally, previous knowledge about possible gender-effect regarding to the LD subtype differences in prevalence of socio-emotional problems is scarce. However, several studies have reported gender differences in socio-emotional problems associated with LD without subgroup comparison. There are also consistent findings on gender differences regarding the prevalence of LD, as well as in addition to prevalence of socio-emotional problems. According to APA (2013), learning disorders overall are more common among males than females and the ratio ranges between 2:1 to 3:1. There seems to be more research conducted about gender differences among children with RD than with other subtypes. Even though the ratio of females to males among children with RD vary depending on the sampling methods and definitional criteria, it has been repeatedly shown that the prevalence of reading difficulties is typically higher among males than females (Arnett et al., 2017; Hawke, Wadsworth, Olson



& Defries; Quinn & Wagner, 2016; Rutter et al., 2004), although there are also findings suggesting that RD would be equally distributed among girls and boys (e.g. Dirks et al., 2008). There is evidence that the male to female ratio increases as a function of greater severity of reading deficits (Hawke, 2007; Olson, 2002; Quinn & Wagner, 2015), and intelligence quotient (IQ) selection when the IQ is above 100 (Olson, 2002). The findings of gender ratio among MD are inconsistent, and they seem to differ depending on the diagnostic criteria. There is evidence suggesting that MD (Devine, Szoltes, Nobes, Gosvami & Szuch, 2013; Gross-Tsur, Manor & Shalev, 1996; Koumoula et al., 2004; Ramaa & Gowramma, 2002) as well as comorbid learning disorders (Moll et al., 2014) might affect both sexes equally. However, there is still lack of consensus regarding this, as there are contradictory research findings suggesting either girls (Dirks et al., 2008; Moll et al., 2014) or boys (Barbarese et al., 2005) being prone to MD.

Regarding the gender differences in mental health problems, there is longstanding support for internalizing problems to be more characteristic for girls, and externalizing problems for boys from multiple cultures and with cross-cultural consistency (Crijnen, Achenbach & Verhulst, 1997,1999; Rescorla et al., 2014). Girls are known to be more prone to depression and anxiety that have a peak onset during adolescence (see Altemusa, Sarvaiya, & Epperson, 2014; see Martel, 2013), and boys for early-onset problems, such as oppositional-defiant disorder, conduct disorder, ADHD, and autism spectrum disorders (see Martel, 2013). Similarly, a Finnish longitudinal study reported that boys in the maladjustment group (those who had more severe socio-emotional problems than the peers or had used mental health services) scored higher in overall externalizing problems and aggressiveness than girls, while girls scored higher than boys in somatic symptoms (Helstelä, Sourander, & Bergroth, 2009).

Finally, the findings from gender differences in socio-emotional problems associated with LD are not as consistent as in relation to whole population. According to Nelson and Harwood's (2011a) as well as Maag and Reid's (2006) meta-analyses examining LD and comorbid depression, many studies did not report their results by gender, and hence, did not permit the examination of gender differences. Nelson and Harwood's (2011b) meta-analysis of anxious symptomatology among students with LD did not find any statistically significant gender differences when examining the ten studies that provided necessary information enabling the within-study comparison of females and males with LD. There are also other studies that reported no gender differences at all in this matter (e.g. Wu et al., 2014). However, some studies indicated that girls with RD are more likely to experience internalizing problems, such as depression or anxiety compared to boys with RD (Nelson & Gregg, 2012; Willcutt & Pennington,

2000b). Heath and Ross (2000) reported that only girls with LD were found to have more depression or higher levels of depressive symptoms compared to the control group, while no group difference was found in the subset of boys. Correspondingly, boys with RD have been found to have stronger externalizing psychopathology and stronger association between RD and ADHD than girls (Willcutt & Pennington, 2000b). In the contrast, there are also opposite results such as findings suggesting that MD girls might have more externalizing problems compared to boys (Wu et al., 2014). Willcutt and Pennington's (2000a) study revealed that RD was associated with inattention in both girls and boys, but with hyperactivity-impulsivity only in boys. Furthermore, the few studies to my knowledge that researched differences in socio-emotional problems as interaction between gender and LD subgroups, did not find statistically significant results (Martinez & Semrud-Clikeman, 2004; Willcutt et al., 2013).

Overall, there are a lot of methodological differences, such as differences in the sample sizes, definitional criteria, used measures, and the informants used, making it hard to draw conclusions of the specific socio-emotional problems additional to distinct deficits, and the possible gender related differences. The sample sizes vary from only 45 participants in Mammarella et al.'s (2016) study to 1023 participants in Willcutt et al.'s (2013) study. There is a wide range of measures used defining both LDs and socio-emotional problems. The Achenbach System of Empirically Based Assessment (ASEBA; Child Behavior Checklist (CBCL), Teacher's Report Form, Youth Self-Report) seems to be commonly used in the assessment of socio-emotional problems (e.g. Auerbach et al., 2008; Willcutt & Pennington, 2000b; Willcutt et al., 2013), while for example Wechsler Individual Achievement test (e.g. Martinez & Semrud-Clikeman, 2004; Wu et al., 2014) and Peabody Individual Achievement test (e.g. Willcutt & Pennington 2000b; Willcutt et al., 2013) were used in the assessment of LDs in more than one study. There are also differences in the informants used among the studies, as self-reports as well as the parent and teacher reports have been utilized. As an example, Arnold et al.'s (2005) findings of higher levels of depression and anxiety among the poor readers compared to the typical readers appeared only in the self-reports, while only parents reported more inattention and delinquent behaviors for the poor reader compared to the typical readers. In general, it is known that the rate of socio-emotional problems found depend on the informant used (Rescorla et al., 2014; Rescorla et al., 2013; Stanger & Lewis, 1993).

Another noteworthy methodological difference between the researches concern the consideration of IQ. There is a long-lasting debate in the research field whether IQ should be used as a definitional criterion (discrepancy criterion) for learning disabilities (see Lyon et al., 2001). Depending on the study, LD has been defined based on the discrepancy between the IQ-score and academic achievement (e.g.

Auerbach et al., 2008; Martinez & Semrud-Clikeman, 2004; Willcutt & Pennington, 2000b), children with low IQ-scores have been excluded from the analyzes with varying cut-off scores (e.g. Auerbach et al., 2008; Mammarella et al., 2016; Willcutt et al. 2013), and/or analyzes have been conducted including IQ as a covariate (e.g. Willcutt et al. 2013). In DSM-5 it is defined that a person diagnosed with SLD should demonstrate normal levels of intellectual functioning, which is generally estimated by an IQ score greater than 70. However, a discrepancy criterion is no longer included to the definition of SLD.

Since there are just a few studies comparing occurrence of socio-emotional problems among the LD subgroups or scrutinizing the mental health differences as interaction of gender and LD subgroups, more investigation is needed to make reliable interpretations. Furthermore, there is no previous comparative study among Finnish children focusing on the subgroup differences between RD, MD and RD+MD in relation to co-occurring socio-emotional problems in childhood. A recent Finnish study (Aro et al., 2018) revealed though that childhood MD was associated with antidepressant use (measured by share of individuals reimbursed for antidepressants) and unemployment in adulthood. Also, a gender <sup>x</sup> subgroup interaction effect was found: the results indicated that men who had RD in childhood were more likely to use antidepressants than men in the RD+MD subgroup, whereas female with childhood RD were less likely to use antidepressants than female in the RD+MD subgroup. As it is found that socio-emotional problems in childhood seem to predict the later mood and anxiety disorders (Roza, Hofstra, van der Ende & Verhulst, 2013) these results as well as the the lack of knowledge about the possible LD subgroup differences in childhood psychological problems aroused interest in the topic of the current study. The aim in this paper was to study childhood LD subtype and gender differences on parent-reported socio-emotional problems in Finnish clinical sample. Mother reports of Child Behavior Checklist- form (CBCL) were used to measure the socio-emotional problems. To gain more knowledge of this topic is important for early identification of the whole complexity of the individual's problems: being aware of the typical co-occurring problems with different LD subtypes might increase the sensitivity to notice them and help to provide right kind of support as early as possible.

The first research question in this paper is *'Do the RD, MD and RD+MD subgroups as well as boys and girls differ in the scores of CBCL Total Problems scale, Internalizing broad-band and syndrome scales (Anxious/Depressed, Withdrawn/Depressed, and Somatic Complaints), Externalizing broad-band and syndrome scales (Rule-Breaking Behavior and Aggressive Behavior), or/and Attention Problem scale, and are the LD subgroup differences related to gender?'* According to the small amount of research, contradictory findings, as well as major variation for example in the sample sizes between

the conducted studies, assumptions of the possible LD subgroup differences, or LD subgroup <sup>x</sup> gender interaction on the measured socio-emotional problems could not be made. However, according to Willcutt & Pennington's (2000b) findings and wider range of previous studies outside the context of LD (e.g. Crijnen et al., 1997, 1999; Helstelä et al., 2009), it was assumed that boys show more externalizing problems than girls in the whole sample. The second research question in this study is *'Are there LD subgroup differences in the number of children experiencing socio-emotional symptoms considered being over the normal variation (i.e., T-value >60) measured with CBCL Internalizing and Externalizing syndrome-scales and Attention Problems scale, and are these differences related to gender?* Since there is no previous research on RD, MD and RD+MD subgroup differences in the number of children experiencing CBCL socio-emotional symptoms classified dichotomously by the severity, no assumptions could be made in this matter. Willcutt et al. (2013) study revealed however that the comorbid LD group was more likely than groups with RD and MD only to meet criteria for DSM based diagnoses, Major Depressive Disorder and Generalized Anxiety Disorder. Although these findings can not be quite generalized to the present research context, it gives indications that there might be subgroup differences also in the current study in the matter of problems exceeding the normal variation.

## **METHOD**

### **Procedure and participants**

The data used in this research were gathered between 1985-2016 at the Niilo Mäki Institute's (NMI) Clinic for Learning Disorders (CLD). The clinic is run jointly by NMI and the Jyväskylä City's Family Counseling Center. It functions in the City of Jyväskylä in Central Finland. The clinic focuses on assessment and interventions of children and adolescents with learning disabilities. The children are typically referred to the CLD for a comprehensive neuropsychological examination based on learning problems recognized at school, often pre-assessed by a school psychologist. Children, that have primarily socio-emotional problems, are not referred to the CLD. The parents of the children have given their informed consent to use the data for research purposes.

The collected clinical archival data has been saved gradually to an electronic database, which by now includes information from about 1180 school aged children speaking Finnish as their first language. All the children in this database who could be identified (see below the definition of RD and MD) as having RD, MD, or both (RD+MD), and who had the CBCL mother's questionnaire data and Full-Scale Intelligence Quotient (FSIQ) information available were included in further analyses. Six hundred and fifty-nine children met these criteria. Children with a Full-Scale IQ score of  $\leq 70$  were excluded from the sample based on the APA's (2013) diagnostic features. The final sample was 618 children (see Table 1 for descriptive information). As five subjects had missing information in some of the measured CBCL scales, the accurate *n* for each analysis will be reported in addition to the analyses and results.

### **Measures**

The measures used in this study were selected based on the neuropsychological assessment performed at the CLD. The independent variables used in this study were LD subgrouping and gender. The dependent variables were T-scores for the CBCL Total, Internalizing and Externalizing broad-band scales along with the syndrome scales Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints,

Rule-Breaking Behavior and Aggressive Behavior as well as the Attention Problems scale. FSIQ score was used as an exclusion criterion.

**Reading and math measures.** In this study the definition for reading disability was that the child scored 1.5 standard deviation (SD) below the reference group mean in one of the reading measures described below. Similarly, math disability was identified if the child scored 1.5 SD below the reference group mean in one of the three math measures. The variety among the tests is due to long time frame in which the data have been gathered as the tests in use in the clinic have changed over the years. To be allocated to the RD+MD subgroup, the child must have scored 1.5 SD lower than the reference group in one of both domain's specific tests. Some of the children had been assessed only in one domain most likely because the previous assessment done by school psychologist had indicated domain specific problems, or teachers reported no problems in the other domain. Therefore, the child was included in this study even if she/he had been assessed only in one domain and scored 1.5 SD lower than the reference group on that, in which case the child was coded to have no problems on the other domain.

The reading measures used to define the LD subgroups in this study were all reading fluency tests developed and age-normed in Finland. Reading fluency is a sensitive measure for reading deficits, as it is shown in several studies that, especially in transparent orthographies, a dyslexic child typically shows accurate word decoding skills but poor reading fluency (e.g. Hautala, Aro, Eklund, Lerkkanen & Lyytinen, 2012; see Wimmer, Mayringer & Landerl, 2000). Finnish children have been found to learn reading accuracy fast, typically by the end of the first grade (Aro & Wimmer, 2003; Aro, 2004). The tests used in this study include text-reading and word-list reading tasks measured with the time taken to complete the task or with the number of correctly read words within a time unit.

The Misku (Niilo Mäki Institute, 1992) task is directed for children between eight to 12-year-olds and the reading fluency is measured by the time taken to complete reading a given one-page text as correctly and fluently as possible. The ÄRPS (Äänekoski Reading Performance Scale, Niilo Mäki Institute, 1994) consists of two tests, text reading and word-list reading tests, which have been developed for second, third and fourth graders, and both subtests were used in this study to define the LD subgroups. The text reading test is a one-page story that the child is asked to read as correctly and fluently as possible. Reading fluency is measured based on the number of words read per time unit. In the word list reading subtest, the measure is the time taken to complete the 20 words list as fluently and correctly as possible. The third and fourth tests used in this study are both word list reading measures. In the Lukilasse (Häyrynen, Serenius-Sirve, & Korkman, 1999), developed for first to sixth graders, the list of words gets

gradually harder, and the measure is the number of correctly read words within two minutes. The Markkinat (Niilo Mäki Institute, 1992-2004) word list reading task was developed for eight to 12-year-old children. The task is to read 13 words as correctly and fluently as possible and the measure is the time taken to complete the task. Some of the children in the clinical data were tested with two reading measures. Overall 73-86% among those children received a congruent “diagnosis” from the differing measures (depending on the combination of the measures), indicating that the distinct measures correlate with each other. The ÄRPS was the most commonly conducted test. Among the used reading measures, reliability coefficients are provided only for the Lukilasse word list reading test: in normative sample the coefficients are reported to range between 0.94-0.98 depending on the school grade (Häyrinen et al., 1999).

Three of the four math measures used to define the LD subgroups in this study were developed in Finland. The Lukilasse Arithmetics Subtest (Häyrinen et al., 1999) includes basic arithmetic operation tasks normed for first to sixth graders. The range of the amount of operations depend from the grade, varying between nine and 10. The RMAT (Räsänen, 1992) test also measures the mathematical abilities with basic arithmetical operations, but it is normed for third to sixth graders. The individual is given 10 minutes time to solve as many operations as possible up to 55. The BANUCA (Basic Numerical and Calculation Abilities, Räsänen, 2005) is a basic numerical and calculation abilities test normed for first to third graders. The standardized part (there is another part which is qualitative assessment) used in this study consists of nine subtests and none of the tasks require text reading skills or linguistic production, rendering it suitable for assessing children who have reading difficulties. The test takes about 20-40 minutes. The fourth math measure used was the arithmetic subtest of the Kaufman ABC (Assessment Battery for Children, Kaufman & Kaufman, 1983), having Finnish norms for second to fifth graders. The arithmetic abilities are measured with 38 tasks. Some of the children in the clinical data were tested with two math measures. Among these children 52-67% received a congruent “diagnosis” from the differing measures (depending on the combination of the measures). The RMAT was the most common math measure used, as it was utilized in 73% of the cases. Among the used math measures, reliability coefficients are provided for all measures. The coefficients in normative samples are reported to range between 0.92-0.95 for the RMAT (Räsänen, 1992), between 0.55-0.84 for the Lukilasse Arithmetics Subtest (Häyrinen et al., 1999), and between 0.89-0.97 for the Kaufman ABC (Kaufman & Kaufman, 1983) depending on the school grade. The reliability coefficient for the BANUCA in normative sample is reported to be 0.83 (Räsänen, 2005).

**Measure of the socio-emotional problems.** The socio-emotional problems used in the analyses were assessed with Achenbach's CBCL/6-18 parent forms. Only mother reports were included in this study as fewer father reports were available. As the data used in this study has been gathered since 1985, the version of the CBCL form has changed twice from the time the oldest data was gathered, and six items were replaced in the latest 2001 version. Parents of the first 213 children included in this study have filled the Finnish version of the oldest CBCL form (Achenbach & Edelbrock, 1983), 253 have filled the 1991 version (Achenbach, 1991), and 152 parents have filled the latest 2001 version of the CBCL form (Achenbach & Rescorla, 2001).

The CBCL includes 112 statements concerning the child's socio-emotional behavior and each statement has three answer options coded as 0=Not true, 1=Somewhat or sometimes true, and 2= Very true or often true. The more the child scores on the questionnaire, the more the problem behavior occur. Eight empirically based syndrome scales as well as broad-band Internalizing, Externalizing, and Total Problems scales have been developed to better organize the information obtained from parents. Syndrome scales Anxious/Depressed, Withdrawn/Depressed, and Somatic Complaints all are included to broad-band Internalizing scale. Rule-Breaking Behavior and Aggressive Behavior are both included in the Externalizing broad-band scale. Besides that, there are Social Problems, Thought Problems, and Attention Problems syndrome scales. The scales used in this study are the Total Problems scale, broad-band Externalizing and Internalizing scales, the empirically based syndrome scales combined in the Externalizing and Internalizing broad-band scales, as well as the Attention Problem scale. These scales were chosen based on the previous support, that internalizing and externalizing problems as well as attention problems have often been found to co-occur with LDs (e.g., Willcutt et al., 2013).

The mother reported CBCL raw scores for each of the scales were converted to age-standardized T- scores (mean = 50 and SD = 10) using American norms (Achenbach & Rescorla, 2001) enabling the use of the information from all three different CBCL versions in the same variable. According to Achenbach and Rescorla's (2001) manual, when dichotomously classifying children's scores the T-scores below 65 can be used to designate the normal range of symptoms measured with the empirically based syndrome scales. T-score below 60 is suggested to be used for designating the normal range of symptoms measured with the Total, Internalizing and Externalizing broad-band scales (Achenbach & Rescorla, 2001). This cut-off is less conservative than the one for the syndrome scales because the broad-band scales include more numerous and diverse problems (Achenbach & Rescorla, 2001). It is pointed out in CBCL manual (Achenbach & Rescorla, 2001) that users can choose lower or higher cut-off scores



for their clinical or research purposes. Even though the American CBCL norms can be used also in Finnish samples (Achenbach & Rescorla, 2007; Rescorla et al., 2007), a T-score over 60 is used to discriminate between deviant and nondeviant scores for each CBCL scale of interest in the current study. A consistent, slightly lower cut-off score in the case of the syndrome scales is considered as a valid decision because the purpose in this study is not to identify the scores that warrant the consideration of needs for professional help (see Achenbach & Rescorla, 2001), but rather to identify the children with higher risk for mental health problems. A too conservative cut-off score could exclude some children belonging to this group. Also, according to Hudziak, Copeland, Stanger & Wadsworth's (2004) study, a T-score of 55 from CBCL Attention Problems scale was enough to discriminate efficiently ADHD cases from non-cases.

The CBCL has been used in many societies researching children's behavioral and emotional problems (Rescorla et al., 2007). It has sufficient cross-cultural consistency (Crijnen et al., 1997, 1999) and more specifically, it has gained evidence of similarity in factor structure, internal consistency and mean scores in many different societies (Rescorla et al., 2007; Ivanova et al., 2007). It has been shown to have good criterion validity being able to discriminate between referred and non-referred children (Ang et al., 2012). Cronbach's alpha coefficients for the CBCL (ages 6-18) broad-band and syndrome scales have been found to be between 0.78-0.97, and test-retest reliability (Pearson correlations) between 0.81-0.94 (Achenbach & Rescorla, 2001).

**Measure of intelligence.** IQ was measured with Wechsler Intelligence Scale for Children. Three different versions were used during the time the data in this sample was gathered (Wechsler, 1974; Wechsler, 1991; Wechsler, 2003). The IQ Full scale score was calculated for those children having the information from all needed indexes in each version, and cases with lacking information were excluded from the study. It is noteworthy that in some cases among those whose IQ was measured with WISC-IV, the FSIQ score was calculated even though the score difference between the distinct cognitive indexes (Verbal Index, Perceptual Index, Working Memory and Processing Speed) exceeded 20.

## **Analyses**

SPSS Statistics 24 was used to perform the statistical analyses in this study. Firstly, the variable distributions were evaluated. As each distribution of the nine depended variables (CBCL T-scores) had

strong positive skewness, Box-Cox and Inverse transformations (see Osborne, 2010) were executed to the T-scores to improve the normality of the data, and to compare which transformation resulted in the best outcome. The histograms and *skewness/std. error of skewness* -value indicated that all distributions were normal or close to normal after both transformations. Box-Cox transformation for Total score and Inverse transformation for all the rest of the CBCL-scales under interest (Internalizing and Externalizing broad-band scales, and Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints, Rule-Breaking Behavior, Aggressive Behavior and Attention problems scale) were included in the statistical analyses as dependent variables based on the smallest *skewness/std. error of skewness* -value.

Analysis of variance (ANOVA) and Multivariate analysis of variance (MANOVA) were used to study the subgroup differences, gender differences, and gender <sup>x</sup> subgroup interaction effect in the T-scores. The Total Problems scores, broad-band Internalizing scores, broad-band Externalizing scores and Attention Problems scores were all analyzed with separate ANOVA analyses. The scores of the Internalizing and Externalizing syndrome scales were analyzed with two separate MANOVA analyses. Bonferroni Post Hoc test was used to analyze differences between the LD subgroups. The found gender <sup>x</sup> subgroup interaction was further interpreted by repeating the ANOVA analysis separately to girls and boys.

Cross-tabulation and  $\chi^2$ -test were used to find out whether the proportions of subjects receiving a T-score >60 (Achenbach & Rescorla, 2001) was dependent on the LD subgroup (RD, MD, RD+MD) and gender. A dichotomic variable was formed to classify children's scores as being clearly in the normal range (T score<60) vs. from the high end of normal range or exceeding it (T score $\geq$ 60). The Internalizing and Externalizing syndrome scales along with Attention Problems scale were included in the analyses, and each scale was analyzed separately. Due to some missing information in some of these scales, there was variation in the sample sizes: the analyses among Aggressive Behavior, Attention problems and Somatic Complaints scales had 617 subjects, the analyses among Anxious/Depressed and Withdrawn/Depressed scales had 616, while analysis among Rule-Breaking Behavior had 615 subjects.

## RESULTS

The descriptive statistics of the sample are reported in Table 1. There was no statistically significant difference in the age between the LD subgroups ( $F(2, 618) = 2.60, p = .075$ , partial  $\eta^2 = .01$ ). Cross-tabulation revealed that the groups differed in the distribution of gender ( $\chi^2(2) = 6.78; p = .034$ ) so that MD group had less boys than expected (22.9%; Adjusted Residual (AdjR) = -2.5), and more girls than expected (32.4%; AdjR = 2.5). The FSIQ scores differed between the LD subgroups ( $F(2, 618) = 10.08, p = .000$ , partial  $\eta^2 = .03$ ). The univariate tests indicated that the children in MD ( $p = .000$ ) and RD+MD ( $p = .004$ ) groups had lower FSIQ scores than the children in RD group. Some statistically significant correlations, even though small, were detected between FSIQ and CBCL scales in the LD subgroups (see Table 2). Therefore, the ANOVA and MANOVA analyses were repeated with FSIQ included as covariate (ANCOVA, MANCOVA). Since only one effect for IQ was detected (see Table 3), the results are reported without IQ covariation and the only IQ effect is pointed out.

**Table 1. Characteristics of the sample: Group means (M), and Standard deviations (SD).**

	RD(n=277)				MD(n=161)				RD+MD(n=180)			
	Boys(n=195)		Girls(n=82)		Boys(n=94)		Girls(n=67)		Boys(n=122)		Girls(n=58)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Age <sup>a</sup>	121.99	15.18	121.48	14.01	122.84	20.05	124.28	16.04	126.17	14.30	123.31	13.79
Grade	3.37	1.34	3.44	1.36	3.51	1.63	3.69	1.33	3.76	1.31	3.66	1.18
FSIQ score	92.89	9.45	91.02	10.53	87.81	10.84	88.13	8.90	89.55	9.64	87.55	8.70

Note. FSIQ score= Full Scale IQ score. <sup>a</sup>= months.

**Table 2. Pearson Correlations between Full Scale IQ and CBCL Problem Scales in each LD subgroup, and the equality of Correlations between subgroups.**

	RD	MD	RD+MD	Equality of Correlations, <i>p</i> -value		
				RD – MD	RD – RD+MD	MD – RD+MD
Total P.	-.105	.160*	-.085	0.004 <sup>a</sup>	0.417	0.012 <sup>a</sup>
Internalizing	-.115	.120	-.027	0.009 <sup>a</sup>	0.180	0.089
Externalizing	-.142*	.183*	-.050	0.001 <sup>a</sup>	0.168	0.016 <sup>a</sup>
Anxious/D	.010	.221*	.000	0.016 <sup>a</sup>	0.459	0.020 <sup>a</sup>
Withdrawn/D	-.126*	.028	-.053	0.061	0.223	0.229
Somatic	-.050	.072	-.004	0.111	0.317	0.243
Aggressive	-.086	.212**	-.086	0.012 <sup>a</sup>	0.215	0.003 <sup>a</sup>
Rule-Breaking	-.074	.217**	-.127	0.002 <sup>a</sup>	0.290	0.001 <sup>a</sup>
Attention P.	-.080	.101	-.072	0.035 <sup>a</sup>	0.467	0.056

Note. \* = Correlation is significant at the 0.05 level, \*\*= Correlation is significant at the 0.01 level. Equality of Correlation= The statistical significance in the difference of Pearson Correlations between two LD subgroup. <sup>a</sup>= Significant (*p*-value  $\leq$  .05) difference between the subgroups.

The first research question concerned mean level differences on the CBCL scales between the LD subgroups. First, ANOVA was used to analyze differences in the T-scores of Total Problems scale, Internalizing broad-band scale, and Externalizing broad-band scale. These analyses showed a main effect for the LD subgroup on the Total Problems scale and Internalizing broad-band scale (see Table 3). Pairwise comparison revealed that children in the MD group had more mother reported symptoms than children in the RD and RD+MD group measured with both scales. The ANOVA analysis for the Externalizing broad-band scale revealed a gender  $\times$  subgroup interaction effect for boys, so that boys in the MD group received higher scores than boys in the RD group (see Table 3).

Second, MANOVA was used separately for the Internalizing syndrome scales (i.e., Anxious/Depressed, Withdrawn/Depressed, and Somatic Complaints), and the Externalizing syndrome scales (i.e., Rule-Breaking Behavior and Aggressive Behavior). In the analysis for the Internalizing syndrome scales the effect of the LD subgroup approached significance (Wilks' Lambda = .98,  $F(2, 618) = 1.98$ ,  $p = .066$ , partial  $\eta^2 = .01$ ). To better understand the above described ANOVA finding showing a subgroup difference in the Internalizing broad-band scale score, the univariate results were

analyzed although they need to be interpreted with caution due to the  $p$ -value  $>.05$  from the Multivariate Test. Further univariate ANOVAs and Post Hoc Tests showed that the LD subgrouping had a statistically significant effect on the Anxious/Depressed scores, so that children in the MD group showed more problems than children in the RD group (see Table 4). MANOVA for the Externalizing syndrome scales showed a main effect for gender ( $F(1, 618) = 4.20, p \leq .05$ , partial  $\eta^2 = .01$ ). The follow-up tests showed an effect for the Rule-Breaking Behavior scale, so that boys had more mother reported symptoms than girls (see Table 4). MANOVAs testing the LD subgroup main effect and subgroup  $\times$  gender interaction effect for the Externalizing syndrome scales, and gender main effect and subgroup  $\times$  gender interaction effect for the Internalizing syndrome scales remained un-significant.

Third, the Attention Problems scale was analyzed with ANOVA. The analysis showed a significant main effect for the LD subgroup (see Table 3). Post Hoc Tests revealed that children in the MD and RD+MD groups had significantly more mother reported problems than children in the RD group. All the analyses in this study were also conducted using IQ as a covariate, but the only effect for IQ was detected in the Attention Problems scale. When IQ was set as a covariate, the previous finding that children in the RD+MD group had more problems than children in the RD group did not remain significant, although it approached significance ( $p=.072$ ). The significant subgroup difference between MD and RD group remained even after controlling for IQ. The Cohen's  $d$  (Cohen, 1988) for all the significant results varied between .27-.45, indicating effect sizes between small and medium.

**Table 3. Univariate LD subgroup comparison on CBCL Total Problems, Internalizing, and Externalizing broad-band scales.**

	RD		MD		RD+MD		LD	Gender	Interaction	Pairwise comparison <sup>a</sup>	<i>p</i> -value (Cohen <i>d</i> )
	M	SD	M	SD	M	SD	( <i>F</i> ( <i>df</i> <sub>1</sub> , <i>df</i> <sub>2</sub> ) = <i>n<sub>p</sub></i> <sup>2</sup> )	( <i>F</i> ( <i>df</i> <sub>1</sub> , <i>df</i> <sub>2</sub> ) = <i>n<sub>p</sub></i> <sup>2</sup> )	( <i>F</i> ( <i>df</i> <sub>1</sub> , <i>df</i> <sub>2</sub> ) = <i>n<sub>p</sub></i> <sup>2</sup> )		
Total	49.32	11.17	53.89	10.76	50.89	11.17	6.89(2; 612) =.022**	2.16(1;612) =.004	2.43(2; 612) =.008	MD>RD MD>RD+MD	.000 (d=.43) .029 (d=.28)
Internalizing broad-band	50.97	10.84	54.28	11.47	51.56	11.29	3.94(2; 610) =.013*	.046(1;610) =.000	1.08(2; 610) =.004	MD>RD MD>RD+MD	.004 (d=.31) .049 (d=.26)
Externalizing broad-band	49.39	12.00	50.78	10.45	50.59	11.34	.84(2; 611) =.011	1.163(1; 611) =.002	4.46(2; 611) =.014*		
Boys	49.01	12.33	52.89	10.90	50.63	11.20				MDboys>RDboys	.003 (d=.42)
Girls	50.28	11.23	47.82	9.07	50.51	11.72					

Note. M= Mean, SD = Standard deviation, F = F-value, df1 = degrees of freedom between groups, df2= degrees of freedom within groups, *n<sub>p</sub>*<sup>2</sup>= Partial Eta Squared, d= Cohen d. Ms and SDs are presented with original T-scores before variable transformation. <sup>a</sup>=Bonferroni correction for significant group differences. \*=*p*≤0.05, \*\*=*p*≤0.01. The distinct scores for boys and girls are reported only for Externalizing broad-band scale as the other scales showed no statistically significant gender x subgroup interaction effect.

**Table 4. Univariate LD subgroup comparison on CBCL Internalizing syndrome scales, Externalizing syndrome scales, and Attention Problems scale.**

	RD		MD		RD+MD		LD main effect ( $F(df_1, df_2)$ $= n_p^2$ )	Gender main effect ( $F(df_1, df_2)$ $= n_p^2$ )	Interaction main effect ( $F(df_1, df_2)$ $= n_p^2$ )	Pairwise comparison <sup>a</sup>	<i>p</i> -value (Cohen's <i>d</i> )
	M	SD	M	SD	M	SD					
Anxious/ Depressed	49.32	11.17	53.89	10.76	50.89	11.17	3.42(2; 610) =.011*			b	MD>RD .005 (d=.30)
Withdrawn/ Depressed	50.97	10.84	54.28	11.47	51.56	11.29	1.09(2; 610) =.004			b	
Somatic Complaints	49.39	12.00	50.78	10.45	50.59	11.34	.53(2; 611) =.002			b	
Rule-Breaking Behavior	51.25	9.94	51.17	8.91	51.65	9.43	b	4.70(1; 609) =.008*		b	
Boys Total		M= 51.91		SD= 9.75							
Girls Total		M= 50.24		SD= 8.22							BOYS>GIRLS
Aggressive Behavior	52.00	11.36	52.58	10.69	53.04	10.41	b	.00(1; 611) =. 000		b	
Boys Total		M= 52.54		SD= 11.33							
Girls Total		M= 52.29		SD= 10.05							
Attention Problems	55.95	10.80	60.96	11.44	58.37	9.89	8.14(2; 611) =.003**	.19(1; 611) =.000	2.23(2; 611) =.007	MD>RD RD+MD>RD <sup>c</sup>	.000 (d=.45) .016 (d=.27)

Note. M= Mean, SD = Standard deviation, F = F-value, df1 = degrees of freedom between groups, df2= degrees of freedom within groups,  $n_p^2$ = Partial Eta Squared, d= Cohen d. Ms and SDs are presented with original T-scores before variable transformation. <sup>a</sup>=Bonferroni correction for significant group differences. <sup>b</sup>= Not reported due to non-significant Multivariate test. <sup>c</sup>= Significant Pairwise comparison result was not found when FSIQ was set as a covariate. \*= $p \leq 0.05$ , \*\*= $p \leq 0.01$ .

The second research question concerned differences between the LD subgroups in the frequency of problems that exceed the defined cut-off score for deviant socio-emotional problems. Cross-tabulation and  $\chi^2$ -test revealed a significant association between the LD subgroups and the CBCL Anxious/Depressed and Attention Problems scales. More individuals than expected in the MD group, and less individuals than expected in the RD group received a T-score >60 on both scales. However, these findings emerged only in the boys group when gender was accounted for (see Table 4).

Also, some other significant findings emerged when crosstabulation was conducted separately for girls and boys, as only girls showed LD subgroup differences concerning the Externalizing syndrome scales. Less girls than expected in the MD and RD+MD groups had a T-score >60 on the Aggressive Behavior scale. More girls than expected in the RD group, and less girls than expected in the MD group had a T-score >60 on the Rule-Breaking Behavior scale.



**Table 5. Adjusted residuals (AdjR) in LD subgroups for CBCL scales.**

				RD		MD		RD+MD	
Socio-emotional problem scales	$\chi^2$	df	n	%	AdjR	%	AdjR	%	AdjR
<b>TOTAL SAMPLE</b>									
<b>Anxious/D.</b>									
Total	8.42*	2	616	13.8	-2.4 <sup>a</sup>	24.8	2.7 <sup>a</sup>	17.8	.0
Boys	8.55*	2	409	13.5	-2.5 <sup>a</sup>	27.7	2.6 <sup>a</sup>	19.7	0.4
Girls	1.46	2	207	14.6	-.6	20.9	1.2	13.8	-.6
<b>Withdrawn/D.</b>									
Total	4.05	2	616	18.9	-.7	25.5	2.0	17.2	-1.2
Boys	4.66	2	409	17.6	-1.7	28.7	2.0	21.3	.0
Girls	4.73	2	207	22.0	1.2	20.9	.8	8.6	-2.2
<b>Somatic C.</b>									
Total	.04	2	617	29.0	-.2	29.8	.2	29.4	.0
Boys	.67	2	410	27.8	-.8	31.9	.5	31.1	.4
Girls	.70	2	207	31.7	.8	26.9	-.4	25.9	-.5
<b>Aggressive B.</b>									
Total	2.97	2	617	17.0	-1.2	18.0	-.4	23.3	1.7
Boys	3.59	2	410	16.5	-1.8	25.5	1.5	22.1	.6
Girls	7.68*	2	207	18.3	0.4	7.5	-2.5 <sup>a</sup>	25.9	-2.1 <sup>a</sup>
<b>Rule-Breaking B.</b>									
Total	.95*	2	615	12.8	1.0 <sup>a</sup>	12.4	-.6	17.8	-.5
Boys	.78	2	408	14.1	-.7	18.1	.8	15.6	.0
Girls	8.59*	2	207	18.3	2.9 <sup>a</sup>	4.5	-2.0 <sup>a</sup>	6.9	-1.1
<b>Attention Problems</b>									
Total	16.99**	2	617	29.3	-3.9 <sup>a</sup>	48.4	3.3 <sup>a</sup>	41.1	1.1
Boys	18.01**	2	410	27.8	-3.8 <sup>a</sup>	53.2	3.6 <sup>a</sup>	40.2	0.8
Girls	1.90	2	207	32.9	-1.4	41.8	.6	43.1	.8

Note. \*= $p \leq 0.05$ , \*\*= $p \leq 0.01$ . <sup>a</sup>=Adjusted residuals  $\geq 2$  tai  $\leq -2$  on scales where  $\chi^2$ - test showed significant result. df= Degrees of freedom.

## DISCUSSION

The purpose of this study was to gain information about the poorly known LD subtype differences concerning the comorbid socio-emotional problems. LD subtypes RD, MD and RD+MD, as well as boys and girls were compared in the co-occurrence of socio-emotional problems measured with CBCL mother reports. The broad-band scales Total problems, Internalizing problems and Externalizing problems, as well as the syndrome scales Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints, Aggressive Behavior, Rule-Breaking Behavior, and Attention Problems were analyzed. The subjects in this study were assessed in their childhood at the NMI's clinic, and were identified having RD, MD or a comorbid condition RD+MD based on those assessments.

According to the results, LD subgroup differences in the co-occurrence of socio-emotional problems were found with small to medium effect sizes. First, the results indicated that children with MD had more socio-emotional problems compared to RD or/and RD+MD groups on several scales. Second, gender main effect, as well as gender-related subgroup differences emerged: boys overall were found to have more rule-breaking behavior than girls, while boys with MD were found to have more externalizing problems than boys with RD. Moreover, some scales indicated that boys in MD group and girls in RD group were prone to clinical range/close to clinical range socio-emotional problems, whereas less MD girls (with and without RD) and less RD boys had clinical range/close to clinical range socio-emotional problems. Next, all the results are discussed in more detail.

In line with the previous research findings (e.g. Nelson & Harwood, 2011b; Nelson & Harwood, 2011a), the results from the present study indicated that LDs and socio-emotional problems often co-occur. However, in more detail, the found LD subgroup differences in the current study, and the few previously conducted studies that also compared the distinct LD subgroups in the matter of co-occurring socio-emotional problems, have all some inconsistencies in the findings. Willcutt et al. (2013) found, with a big sample size, that children in the comorbid subgroup (RD+MD) had more socio-emotional problems than children in the RD only and MD only subgroups. Martinez and Semrud-Clikeman's (2004) study, with small sample size, indicated no subgroup differences at all. On the contrary, the present findings showed that children in the MD group had more overall socio-emotional and internalizing problems than RD and RD+MD groups, and more anxious/depressed and attention problems than children in RD group. Also, the present results suggested that children with RD+MD had

significantly more attention problems compared to RD group: however, this finding did not remain significant when IQ was set as a covariate.

The fact that Martinez and Semrud-Clikeman's (2004) study did not show any subgroup differences might be due to small sample size. They used also the discrepancy criterion (see Lyon, 2001) in defining the LD subgroups which was not applied in the current or Willcutt et al.'s (2013) study. In fact, the APA's fifth edition no more defines LDs with the discrepancy criterion (APA, 2013). Nevertheless, even in the Martinez and Semrud-Clikeman's (2004) study RD+MD group was the only LD subgroup having significantly more emotional symptoms compared to the controls indicating that comorbidity of learning problems would be significant in terms of co-occurring socio-emotional problems.

Even though the current study and the Willcutt et al. (2013) studies both showed LD subgroup differences, it is interesting why in the present study the MD group, instead of the comorbid group with wider learning problems, showed more socio-emotional problems than the other subgroups, while in the Willcutt et al.'s (2013) study the comorbid group had the most co-occurring socio-emotional problems. The difference between the results from Willcutt et al. (2013) and the present study might be due to divergent definitions of RD and MD: in Willcutt et al.'s (2013) study RD and MD were defined by a cutoff score 1.25 SD below the estimated population mean, while the cutoff score used in the current study was 1.5 SD below the reference group mean. Willcutt et al. (2013) also excluded participants with a full-scale IQ score below 75, while in the present study all the children with a full-scale IQ score 70 or below were excluded (see DSM-5, diagnostic features for SLD). Furthermore, Willcutt et al. (2013) study measured the RD with word reading tests, assessing the word recognition and pronunciation ability, while the current study measured reading fluency as it is known to be a common problem among Finnish RD children (Hautala et al., 2012). This might have resulted in divergent RD groups between the studies. Also, the used math measures differed, which might have resulted in divergent MD groups and ultimately to the discrepant research findings depending on the study. This conclusion is supported by previous findings indicating heterogeneity in cognitive profiles among MD children (Geary, 1993), and that different groups of children have been found to meet criteria for MD depending on measures used for the identification (Mazzocco and Myers, 2003).

Additionally, the studies have used at least partly divergent measures for socio-emotional problems, and even those measures that are same have been used differently. Moreover, the informants used among these studies differ. Willcutt et al. (2013) created a composite measure from ASEBA parent

and teacher ratings and reported only the results of broad-band Internalizing and Externalizing scales, while in the current study only mother reports were included, and the results were reported not only on the level of broad-band scales but also more specifically concerning the syndrome scales. Martinez and Semrud-Clikeman's (2004) study assessed the students with self-reports of the Behavior Assessment System for Children. As parent-teacher-child agreement is known to be modest (Rescorla et al., 2014; Stanger & Lewis, 1993), it is likely that the variety in the informants used among the studies have affected the findings received from each research. CBCL scores have been found to be higher than Teacher's Report Form scores across multiple societies (Rescorla et al., 2014), while children are found to report the most problems and teachers the least problems (Stanger & Lewis, 1993). Furthermore, in addition to the ASEBA ratings, Willcutt et al.'s (2013) study utilized the Diagnostic Interview for Children and Adolescents to assess the DSM based disorders. Neither the current study or the Martinez and Semrud-Clikeman's (2004) study included the assessment of DSM diagnoses, except ADHD in the Martinez and Semrud-Clikeman's (2004) study.

Overall, the discrepant results among the studies concerned might be due to several factors such as modest cross-informant agreement, differences among the used measures or varying sample sizes across the studies that must be taken into account when discussing the generalizability depending on the study. It is also essential that unlike the two previous studies (Martinez & Semrud-Clikeman, 2004; Willcutt et al., 2013), the current study is based on a clinical sample. The present findings might be affected by the referral bias, as all the children in the sample were referred to the CLD due to learning problems identified in school. Additionally, it is noteworthy that children that have primarily rather socio-emotional problems than LDs are not referred to the CLD, and therefore it might be that those children who have the most difficult socio-emotional problems comorbid to LD are not included in this sample. Based on the findings from the Willcutt et al.'s (2013) study, this sighting raises a question whether these children (who are not referred to the clinic because of prominent socio-emotional problems) might often have also comorbid LD (RD+MD) that is not the primary concern of those children, resulting to relatively small size of the RD+MD group in this study, and to incapability of the present study to show the possible stronger association between RD+MD group and socio-emotional problems compared to the other LD subgroups.

Nevertheless, it is interesting whether MD might have such features that predispose the children for more socio-emotional problems, resulting in findings that either MD group (as in the present study) or comorbid group (Willcutt et al., 2013) would be most prone to the co-occurrence of such problems.

This suggestion is compatible with a recent Finnish study (Aro et al., 2018) indicating that antidepressant use is more common among adults with known childhood MD than adults with childhood RD. It is noteworthy that the children data used in Aro et al.'s (2018) study was from the same database than the present study, and therefore also the LD measures used matched to the measures used in the present study. Hence, it is likely that the LD groups between these studies are highly comparable. Based on the findings from the present study and the Aro et al.'s (2018) research, it might be that the children with MD, found to have more co-occurring socio-emotional problems than the children with RD in the current study, might have also more continuous socio-emotional problems towards adulthood. There are previous research finding in general indicating that socio-emotional problems reported by parents in childhood predict the later mood and anxiety disorders in adolescence and young adulthood (Roza et al., 2013). However, more research is needed to do such conclusions as there are many factors, beyond those that could be controlled in these studies, that could have influenced to the adulthood outcomes. Also, as the previous findings indicate that either MD or comorbid RD+MD would be risk-factors in the co-occurrence of socio-emotional problems and LDs, it is interesting whether domain specific anxiety/math anxiety might have a role in these results (as math anxiety has not been controlled in the presented studies). In fact, there are findings showing that children with MD have more math anxiety than the controls (Wu et al., 2014), and that anxiety about math-related situations is associated with lower arithmetic skills (Sorvo et al., 2017).

The current finding of more anxious/depressed problems associated with MD compared to RD group has to be interpreted with caution, because the multivariate test result for the Anxious/Depressed, Withdrawn/Depressed and Somatic Complaints scales showed a significance of .07. Despite this, the results were further interpreted to better understand the broad-band scale finding showing a significant subgroup difference in the Internalizing scores. It seems that the results show a stronger subgroup difference when analyzing the Internalizing broad-band scale where all the points received from the statements in the syndrome scales are summed up, than in the case where these statements are divided to the distinct syndrome scales and treated separately. Based on these findings, it might be that speaking of 'overall internalizing problems being more common among children with MD than among children with RD' is more precise than isolate the withdrawn/depressed and somatic complaints symptoms from this concept. Despite this, it seems that anxious/depressed symptoms play a biggest role, as a single syndrome scale, in this entirety.

Furthermore, it is not surprising that besides anxious/depressed problems, children with MD in the current study seem to be prone also to other socio-emotional problems, as they were found to have more attention problems than children with RD. It is well known that socio-emotional problems, as well as overall mental problems tend to co-occur (Pennington et al., 2005; Pesenti-Gritti et al., 2007). However, this finding raises a question whether attention problems might mediate the anxious/depressed problems found in association to MD group: in Willcutt et al.'s (2013) study it was found that specifically in the group with MD only the children with comorbid ADHD had higher rate of Generalized Anxiety Disorder (GAD), whereas in both groups with RD the rate of GAD was similar between the groups with and without ADHD. However, the rate of depression was found to be higher in all the LD subgroups, whether or not meeting the criteria for ADHD compared to the controls. Nevertheless, it is possible that to some extent the found anxious/depressed problems among the children in the MD group in the current study are result from them having also more attention problems. This might have affected to the found LD subgroup difference.

Along with the LD subgroup differences, the current study found gender differences and gender-related LD subgroup differences concerning the co-occurring socio-emotional problems. The found gender main effect indicating that boys have more rule-breaking behavior than girls, is similar with earlier LD research (Willcutt & Pennington, 2000b), even though the Willcutt and Pennington (2000b) study showed gender main effect for the CBCL Externalizing broad-band and Aggressive Behavior scales, not for Rule-Breaking Behavior scale. The current finding is also compatible with findings outside the LD context showing that boys in general have more externalizing problems than girls (e.g. Crijnen et al., 1997; Helstelä et al., 2009; Rescorla et al., 2014).

Furthermore, the current interaction findings indicated that boys with MD have more overall externalizing problems than boys with RD. Also, more boys than expected in the MD group, and less boys than expected in the RD group had anxious/depressed symptoms and attention problems in or close to the clinical range. These findings suggest that the socio-emotional problems found would emerge especially in association to MD boys, and that they would have also more severe problems than the boys with other LD subtypes. In contrast, more girls than expected in RD group had clinical range or close to clinical range aggressive behavior, and less girls than expected in the MD and RD+MD groups had rule-breaking behavior and/or aggressive behavior close to or in the clinical range, suggesting that more RD girls would have severe aggressive behavior compared to girls with other LD subtypes. These findings were not in line with the previous research as Willcutt et al. (2013) and Martinez and Semrud-Clikeman

(2004) did not find subgroup  $\times$  gender interaction at all in their samples. Also, the recent Aro et al. (2018) study found rather contradictory subgroup  $\times$  gender interactions compared to the findings from the present study: their findings indicated that childhood RD poses a higher risk for males in early adulthood than RD+MD, while childhood RD+MD poses a higher risk for females in early adulthood than RD when speaking of antidepressant use.

Firstly, the differing findings among the current study and the previous studies concerning the subgroup  $\times$  gender interaction might be due to the same methodological and research design differences discussed earlier. However, even though not being researched in this study, it is noteworthy that since there are previous indications that externalizing problems among LD subtypes may be mediated by ADHD (Willcutt & Pennington, 2000b; Willcutt et al., 2013) it is possible that also the present subgroup  $\times$  gender interaction finding on externalizing problems is associated to the attention problems found, showing more boys in the MD group receiving a T-score  $>60$  on Attention Problems scale than boys in other subgroups. As CBCL Attention Problems scale has moderate sensitivity and specificity in diagnosing ADHD (Chang, Wang & Tsai, 2016; Puustijärvi, 2016) and a T-score of 55 from CBCL Attention Problems scale has been found to be enough to discriminate efficiently ADHD cases from non-cases (Hudziak et al., 2004), the finding from the current study indicate that more children among the MD boys than among boys with other LD subtypes have symptoms meeting the ADHD. This might explain the different findings between the current study and Willcutt et al. (2013) study, as ADHD was controlled in the Willcutt et al. (2013) research. However, based on the information provided in the paper of Martinez & Semrud-Clikeman's (2004) research, ADHD was not controlled for in their study, still resulting in finding of no subgroup  $\times$  gender interaction. On the other hand, even though not studying the subtype differences, Arnold et al. (2005) and Auerbach et al. (2008) studies revealed that even after controlling for the ADHD the persistence of dyscalculia in the Auerbach et al.'s (2008) study and reading status in the Arnold et al.'s research remained as significant predictors for co-occurring externalizing problems. These findings support the concept that externalizing problems that co-occur with LDs would be independent, at least in some extent from the attention problems co-occurring with LDs.

Secondly, even though the interaction findings from this study are somewhat surprising compared to the findings from Aro et al. (2018) research, it seems also natural that as the research settings, outcome measures and data-analyses differ between these studies, similar findings can't quite be expected. The current study used partly the same participants than the Aro et al.'s (2018) research, however the present study analyzed the subjects in their childhood, while Aro et al. (2018) studied the

adulthood outcomes. There are several circumstances, such as environmental factors, increasing academic requirements or possible interventions the individual is provided with, that could explain why some of the interactions might alter over the years. For example, even if MD boys are prone to externalizing problems in childhood compared to boys in other subgroups, it might be that since these problems are easily identified by teachers (Soles, Bloom, Heath & Karagiannakis, 2008), MD boys might get support more easily than less externalizing children, such as boys with RD according to this study. This might reduce the problems among MD boys, and simultaneously place RD boys at risk later in adulthood, as they might have received less support during the school years. Further, longitudinal research is needed to find out the possible developmental factors affecting the relationship between LDs and co-occurring socio-emotional problems over the years.

In terms of the discrepant findings between the present study and Aro et al.'s (2018) research in the results of gender  $\times$  subgroup interaction among girls, it might be that the Aro et al.'s (2018) finding suggesting that RD+MD poses a higher risk for females in early adulthood than RD concerning antidepressant use, is not apparent yet in childhood as depressive disorders are known to have peak onset in adolescence and early adulthood (see Altemusa et al., 2014; see Martel, 2013). It would not be surprising that over the years when the academic requirements increase, girls in comorbid LD group, with problems in more than one domain and with greater problems than individuals with LD in single domain (Dirks et al., 2008; Willcutt et al., 2013), might be at risk having early adulthood internalizing problems. It is known that girls generally have more internalizing problems than boys (Crijnen et al., 1997; Rescorla et al., 2014).

In addition, this discrepancy might also be due to teachers' weak identification of the problems in childhood. Teachers might expect MD to show more likely among girls than RD, as there is some support for girls having more MD than boys (Moll et al., 2014), and strong support for boys having more RD than girls (Arnett et al., 2017; Hawke, 2007; Quinn & Wagner, 2016; Rutter et al., 2004). Therefore, they might direct more attention and support to girls whom they suspect having math problem, than to other girls with possible other learning problems. Hence, RD among girls might not be recognized as soon as MD, resulting to little support directed to them and to the co-occurrence of frustration and aggressive behavior in childhood related to RD girls.

Moreover, it is interesting that in Soles et al.'s (2008) study girls were more likely to report severe depressive symptoms than boys, while there was no significant difference between the teachers' ratings between boys and girls. However, based on teacher ratings, girls had more severe externalizing behavior



compared to boys. It is suggested in their paper that externalizing problems may have in fact internalizing problems behind them, which teachers did not identify. Therefore, it is also possible that the current finding of severe aggressive behavior problems among RD girls include also internalizing problems that were not recognized by mothers.

There were limitations in the present study that should be taken into consideration when interpreting the results. As the data has been gathered since 1985 along with clinical work, the measures used have changed over time. The variation among the measures defining RD and MD between the individuals might have an effect to the comparisons made across the sample. However, as a majority (73%) of the individuals in the clinical data were tested with the RMAT to assess the mathematical skills, the variation among math measures in the sample affects in fact only a minority of the sample. Also, as 47% of the individuals were tested with the ÄRPS to assess the reading skills, and since 73 to 86% of those children who were tested with two reading measures received a congruent outcome from both, the variation among the reading measures is not either considered as major influential factor. Additionally, as the sample was from clinical data there might be several limitations, such as referral bias, that follow. The children in this study are referred to learning disability assessment, and therefore it is possible that the sample includes more individuals having easily recognizable problems, such as externalizing problems, than a population based randomized sample would include. Also, the size of the subgroups differed. Furthermore, a control group would have allowed the interpretation of the amount of socio-emotional problems comorbid to the LD subgroups compared to controls, even though the used cut-off score for clinical range or close to clinical range problems (Achenbach et al., 2001) enabled the identification of socio-emotional problems exceeding the normal variation.

However, the current study had also major strengths. It not only supplements the lacking knowledge of LD subtype differences concerning the comorbid socio-emotional problems, but it includes the comorbid group RD+MD, adding importance on this study. Also, the sample of this study was large ( $n=618$ ). Even though Willcutt et al.'s (2013) study used a sample size of 1023, many of the previous studies have had relatively small sample sizes (e.g. Auerbach et al., 2008; Mammarella et al., 2016; Martinez & Semrud-Clikeman, 2004; Panicker & Chelliah, 2015). Moreover, this research has an important role in the Finnish context, as learning problems and especially RD might manifest differently with Finnish children compared to children speaking non-transparent languages: unlike the previous studies the current study measured mostly reading fluency, which is a sensitive measure for reading deficits especially in transparent orthographies (Aro & Wimmer, 2003; Aro, M. 2004), giving valuable

indications of the LD subtype differences among Finnish children. Finally, the current study measured the socio-emotional problems not only with CBCL broad-band scales, but also with wide range of CBCL syndrome-scales providing a precise but broad understanding of the LD subtype differences in co-occurring socio-emotional problems.

As a conclusion, according to the current study children with MD might have more certain socio-emotional problems recognized by mothers than children with RD, and that especially boys with MD seem to be prone to these comorbid problems or have more cases with comorbid symptoms exceeding the considered normal range in a context of Finnish clinical settings. As the conclusions so far are made based on few studies with contradictory findings, the information provided by the current study should encourage further research: the present findings must be confirmed, if possible by using a non-clinical sample, to make wider generalization. The current findings can be considered to represent reliably the parent reported socio-emotional symptoms among children with distinct LD, as mothers and fathers have been found to show a high agreement in their ratings (Stanger & Lewis, 1993). However, as cross-informant agreement is generally known to be quite modest, a multi-informant approach would provide a broader view from the individuals problems. Additionally, further research is needed to find out whether math anxiety has a role in the found LD subgroup differences, whether different types of MD and RD co-occur with variant socio-emotional problems, and the role of ADHD as a mediator in LD subtype differences concerning the comorbid socio-emotional problems. Longitudinal approach is needed to find out the developmental processes affecting the relationship between LDs and socio-emotional problems. Understanding of these developmental factors is valuable in directing the best possible support and interventions to the individuals in need, and to minimize the negative adulthood outcomes.

The current study, as also the further study in this area, is in high importance: the possible LD subtype differences in the co-occurring socio-emotional problems should be identified as early as possible in the child's development to prevent and reduce the comorbidity of problems, as well as the children and their families should be supported to manage and understand the comorbid symptoms. The knowledge about the possible associations between certain comorbid symptoms and a specific LD subtype might help to direct the concern also to those children that would not be otherwise identified as having comorbid problems by parents or school. Furthermore, the findings from the LD subtype differences in this matter should be considered when planning the educational or mental health support for children with distinct LDs in the future.

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