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Systematic Review of Factors Impacting Reading Impairment Rates in Studies of Children with Developmental Language Disorder (DLD)

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Abstract

Purpose - This systematic review examined studies of individuals with developmental language disorder (DLD) to examine the rate of co-occurring reading impairment. We hypothesized that recruitment method, age, and the type of diagnostic reading assessment would be associated with different rates of reading impairment in individuals with DLD.

Methods - We searched the database PsycINFO for peer-reviewed academic articles containing specific keywords related to DLD/SLI and Dyslexia, resulting in a total of 286 studies. These articles were then filtered to ensure that all articles analyzed in the present study only examined children below the age of 18, were a study of children with DLD/SLI, included a reading measure, were written in English, and stated the number/percentage of children with comorbid DLD/SLI and reading impairment. We organized the data in a chart that focused specifically on the following factors: recruitment method, mean age, and type of diagnostic reading assessment.

Results - Caseload studies were the most common article in our review and they tended to have higher rates of comorbidity than any other type of study. Additionally, comorbidity rates tended to increase with age, and word reading assessments tended to have lower comorbidity rates than those determined by reading comprehension. However, there was a lot of overlap in comorbidity rates across all studies.

Implications - This study sheds light on the co-occurrence of DLD/SLI and reading impairment and the importance of providing these children with written language support. It also brings awareness to the influence that methodological decisions related to recruitment/assessment methods might have on a study sample. This influence may lead to higher or lower reported comorbidity rates and potentially impact the conclusions drawn related to DLD/SLI.

Introduction

Proficiency in language is a hallmark to relational and academic success, laying the foundations for social competency and education (Asher & Gazelle, 1999; Herbert-Myers et al., 2006). However, some children are diagnosed with a language disorder that impairs their abilities in these domains (Catts et al., 2002; Durkin & Conti-Ramsden, 2007; Grove et al., 1993; Hadley & Rice, 1991).

Developmental Language Disorder (DLD) is one such impairment and is defined as language deficits below that expected of a child's age in the absence of a biomedical condition (Norbury, n.d.). Until recently, most research on children with DLD used the term Specific Language Impairment (SLI). SLI is defined as difficulties with language that cannot be explained by hearing loss or cognitive/intellectual disabilities (National Institute on Deafness and Other Communication Disorders [NIDCD], 2019). Although DLD and SLI are conceptually similar, most research on SLI has excluded children with below-average nonverbal intelligence, whereas DLD does not and includes children with below average nonverbal intelligence as long as this deficit is not the result of a biomedical condition. The specific underlying cause of DLD is still unknown but theories proposing issues with verbal processing and linguistic knowledge have been suggested (Leonard, 2014).

DLD and SLI diagnoses focus specifically on oral language deficiencies, but children with oral language problems often demonstrate issues with reading and writing in the school years. For example, McArthur et al. (2000) examined rates of reading disability in children who had been identified with SLI, and vice versa and found an overlap of approximately 50%. McArthur et al. (2000) questioned whether "specific reading disability" (also known as dyslexia) and SLI were actually distinct disorders. Dyslexia is a disorder centered on language deficits in

printed-word reading despite adequate instruction and normal nonverbal intelligence (Lyon et al., 2003). This difficulty with reading is the result of word recognition, spelling, and decoding problems that are theorized to be the consequences of an underlying phonological deficit (Lyon et al., 2003). Dyslexia and DLD/SLI are often studied separately, but their overlap has prompted theories regarding the interrelationship of these disorders.

One of the early theories proposed to explain this finding was the "severity" hypothesis put forward by Kamhi & Catts (1986), stating that children with both DLD/SLI and Dyslexia would exhibit reading issues rooted in phonological deficits, but children with DLD/SLI would have more severe deficiencies that result in additional oral language problems. Another theory circulated to explain the overlap was the partial distinction hypothesis suggested by Bishop & Snowling (2004), positing that both children with DLD/SLI and children with Dyslexia would display phonological deficits that result in reading difficulties, but children with DLD/SLI would have additional cognitive deficits outside of the phonological domain that create their oral language impairment. However, Catts et al. (2005) challenged these theories by hypothesizing that the overlap in reading impairment is manifested in comorbidity and that some children with DLD/SLI have intact phonological skills. They put children with DLD/SLI-only, Dyslexia-only, and children with both DLD/SLI *and* Dyslexia in separate groups and tested their phonological word reading skills, discovering that the Dyslexia-only and DLD/SLI+Dyslexia groups scored poorly whereas the SLI-only group performed within the normal range. Catts et al. (2005) suggested that the phonological impairments seen in some children with DLD/SLI were actually the result of concomitant Dyslexia and that they are not an underlying cause for the oral language impairments seen in DLD/SLI. This contradicted both the severity hypothesis and partial distinction hypothesis because both posited that all children with DLD/SLI had phonological

impairments. More recent studies have confirmed that DLD and dyslexia are separate but frequently co-occurring disorders, but their findings regarding phonological deficits of children with DLD/SLI have been mixed (see Ehrhorn et al., 2020).

It is important that studies of DLD and dyslexia consider the potential comorbidity of these disorders; when they do not, features of one disorder might influence results for studies of the other. Studies that have considered the potential comorbidity of DLD and dyslexia have reported varying rates. As mentioned above, McCarthur et al. (2000) reported a rate of 51%, whereas Catts et al., (2005) reported rates of 17-36% depending on age and the way that dyslexia was defined. Because of this variability, understanding potential factors that might influence the rate of comorbidity in study sample's rates is important.

One possible component that might impact a sample's comorbidity rate is how participants are recruited. Participants selected from clinical populations are likely to have more severe and concomitant disorders than participants selected from population-based samples (Berkson, 1946). Therefore, if children with DLD/SLI are recruited from a clinical caseload, then they may be more likely to have comorbid Dyslexia. A few studies examining reading impairment in children with DLD/SLI have used community or population-based samples (e.g., Catts et al., 2005; Bishop et al., 2009; Adlof et al., 2017). In McArthur et al., (2000), participants were recruited from language centers for children with DLD/SLI and had much higher comorbidity rates than in Catts et al., (2005) which recruited from a population-based sample. However, Adlof et al. (2017) utilized similar methods of participant selection as Catts et al. (2005), recruiting children from second grade classrooms, and their rate of comorbidity was similar to that of McArthur et al. (2000). As a result, the influence that recruitment method might have on comorbidity rates is still unclear and requires further research.

Additionally, age may play an influential role in reported comorbidity rates. In Bishop et al. (1990), a study of children with DLD/SLI at 8.5 years old, comorbidity rates were as low as 8.5%. However, in a follow-up study conducted by Snowling et al. (2000) with the same participants at 15 years old, the comorbidity rate had increased to 43%. Snowling et al. (2000) also excluded participants from the original study that displayed below average nonverbal intelligence (NVIQ) and yet it still had higher rates of comorbidity. This increase in comorbidity may be the result of testing children for reading impairment at different stages of reading development. When a child is in the early phases of reading development, instruction is focused on learning how to decode words and phonological skills are imperative for this task. However, as a child develops word reading fluency, oral language skills become the primary influence on reading comprehension (Adlof, Perfetti & Catts, 2011; Foorman, Petscher, & Herrera, 2018). Some studies (Bishop et al., 2009; Kelso et al., 2007; Ramus et al. 2013) have linked DLD/SLI children - with and *without* Dyslexia - to comprehension issues. Therefore, if older children need to rely more on comprehension skills for reading, and comprehension deficits have been linked to most children with DLD/SLI, then perhaps the comorbidity rates for DLD/SLI and Dyslexia will increase with age. Although, Catts et al., (2005) did not find that comorbidity rates changed much over ages. It is important to examine this in other samples.

Lastly, the type of reading measure used to determine Dyslexia may influence the reported rate of comorbidity. As was mentioned previously, children with DLD/SLI with and without a concomitant Dyslexia diagnosis tend to have comprehension deficits (Bishop et al., 2009; Kelso et al., 2007; Ramus et al. 2013). Therefore, if reading impairment is determined by tests utilizing reading comprehension, perhaps rates of comorbidity will be greater in these studies than in studies using word- or nonword-reading tests.

In this systematic review, we examined studies that reported rates of comorbidity for children with DLD/SLI and reading impairment, focusing on the features of the studies that might influence these rates. We specifically looked at how different recruitment methods, participant ages, and reading measures impact reported comorbidity. We hypothesized that in this review, comorbidity rates would generally be greater in caseload studies because participants would be more likely to have more severe deficits and concomitant disorders (like reading impairment). Additionally, because children with DLD/SLI tend to have deficits in comprehension - both in the presence and absence of phonological issues - we theorized that higher comorbidity rates would be observed in studies with older children and in studies that used comprehension as a method of determining reading impairment.

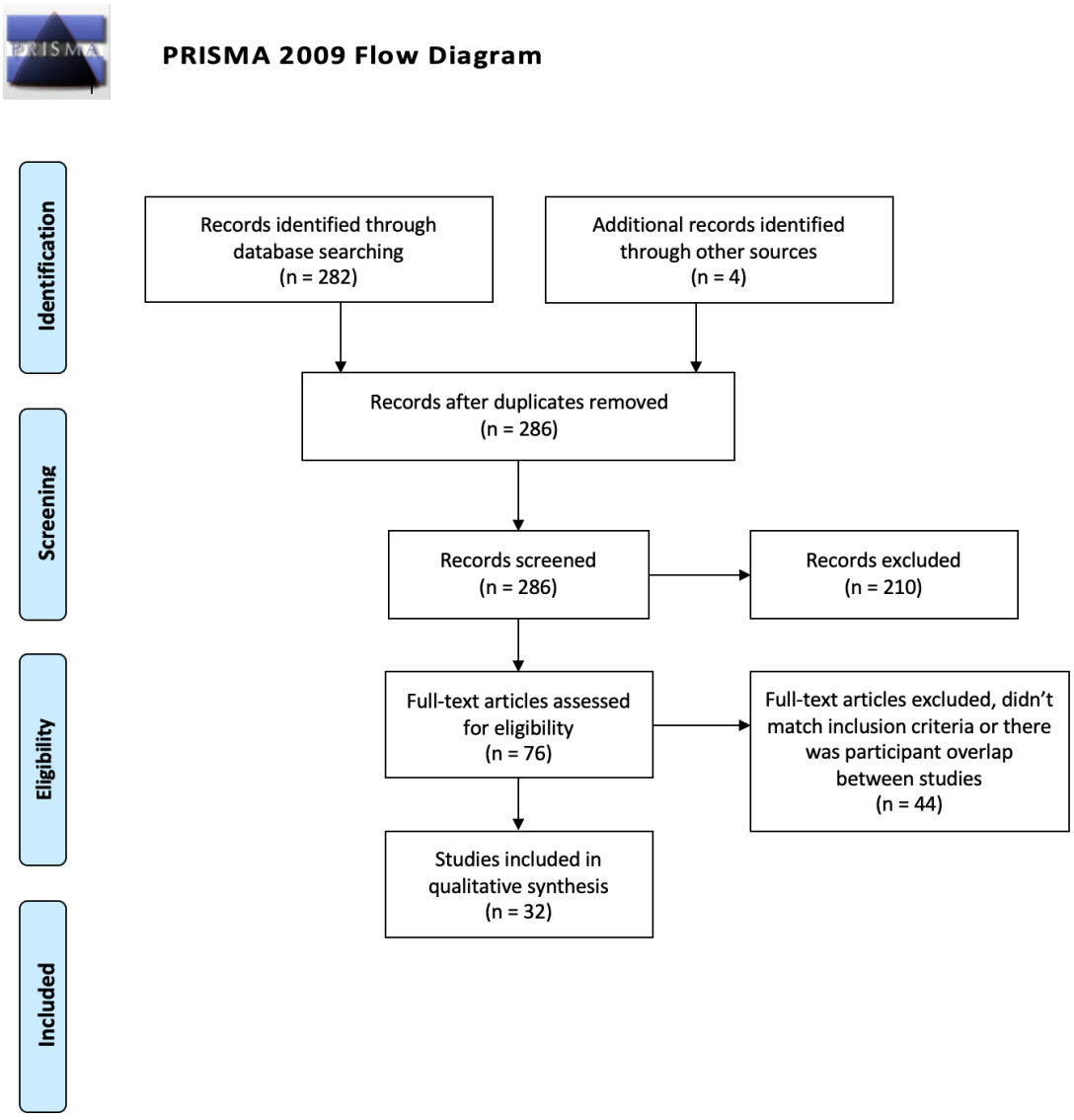
Method

A systematic search of PsycInfo was conducted on November 20, 2020 using keywords related to DLD/SLI and Dyslexia in peer-reviewed study abstracts to create a total pool of 282 articles. Articles were found by searching “developmental language disorder” or “specific language impairment” or “language disorder” AND “dyslexia” or “reading disorder” or “learning disability” or “reading disability” from 1980 to the present. While reviewing the initial pool of 282 articles, we discovered a review of 4 additional articles that met our inclusion/exclusion requirements but were not found by our search. All 4 articles were then added to the original search to create a final total of 286 articles.

To be included in the systematic review, studies had to a) have been published in a peer-reviewed journal from 1980 to November 2020, b) be written in English, c) examine children with DLD or SLI, d) include a reading measure, and e) explicitly state the rate of children with

DLD/SLI who also have a reading impairment. All studies included in the final review excluded children with communication issues that could be explained by other factors such as traumatic brain injuries (TBI), Autism Spectrum Disorder (ASD), Down syndrome (DS), etc.

In the first round of initial screening, 210 records were excluded by completing quick reviews of each article, focusing on all criteria except whether or not an exact rate was stated in the paper. In the second round, the papers were fully analyzed to ensure that an exact rate was stated, that the rates were analyzing children with DLD/SLI who have a concomitant reading impairment, and to identify studies with participant overlap and select the appropriate study for inclusion. If there was participant overlap between studies, we included the study with the largest sample of children with DLD/SLI. The two exceptions to this rule were Snowling et al. (2000) which used the same participant sample as Bishop & Adams (1990), and Catts et al. (2005) and Alonzo et al. (2020). Both pairs analyzed the rates of comorbidity at different periods of time and because age was a factor that we were interested in reviewing in this study, we included all four articles. This left us with a final total of 32 articles.



After we identified the 32 articles that met our search criteria, the articles were coded and data was entered for the following variables: age, language spoken by readers, recruitment source, nonverbal intelligence measure, method of diagnosis for DLD/SLI, method of determining reading impairment, and rate of comorbidity (see Table 1). Additionally, the researcher tracked other notes about the studies and other administered assessments in a separate column that is not reported in this document.

In table 2, we specifically analyzed the recruitment method, mean age, and type of diagnostic reading assessment for each study. Recruitment method was classified into the

following categories: community samples, caseloads (children already diagnosed with a language impairment), a mixture of any of these methods, or "unknown." Only one study fell under the "unknown" category.

Because many of the studies utilized a range of ages in their experiments, in order to quantify this factor we classified participants into age categories by the reported mean age. Even though this does not fully represent each group of participants, only 6 records had a range greater than or equal to 5 years and most other studies that included multiple ages were within a range of 3 years. We created categories for 5-6.99 years, 7-8.99 years, 9-10.99 years, and 11+ years. Our rationale for the creation of these groups was to see children in each stage of reading development, from pre-reading/decoding to comprehension. If the study did not provide a mean age for the participants, it was placed under the "unknown" category.

We classified reading assessments as measuring word reading, reading comprehension, and any combination of word reading, spelling, and/or reading comprehension. The rates of comorbidity associated with these three classifications were then calculated and inputted into our final table. If a study provided multiple rates of comorbidity for different subgroups of participants with DLD/SLI, an inclusive total of all subgroups was calculated and reported separately (see Table 2). Summarized results reported in the results section of this paper are based on the inclusive total from each study.

Results

As shown in Table 1, most studies focused on children aged 7-8.99 years (15/32 studies, (47%)). The majority of studies involved students who spoke English (24/32 studies, (75%)), with 8/32 studies (25%) involving children speaking either Dutch (2/32), French (1/32), Spanish

(1/32), Greek (2/32), or Mandarin (2/32). Most studies recruited participants with language impairment from clinical caseloads (22/32 studies, (69%)), whereas 7/32 studies (22%) used community based sampling, and 2/32 used a mixture of caseload and community recruitment. Only one study did not explicitly state how they recruited their participants.

Language impairment status was most often determined by versions of the Clinical Evaluation of Language Fundamentals (CELF) with 11/32 studies (34%) using this test in some way to help create their DLD/SLI diagnostic group. All studies excluded children with developmental histories that could explain a language deficit (e.g., diagnosis of ASD, DS, or a past TBI). Additionally, most studies excluded children with abnormal NVIQ, although the specific cutoffs for "abnormal" scores varied across studies. The majority of studies only had children who either exhibited “average nonverbal intelligence” as defined by the author(s) or had a specific IQ cutoff that the children had to meet (26/32, (81%)), however a few studies did not have these requirements (3/32) and a few studies had a separate category for the children with DLD/SLI who scored below a certain IQ cutoff (3/32). Note that the participants Catts et al. (2005) scored above a nonverbal IQ cutoff in kindergarten, and their nonverbal IQ was retested in later grades . For the studies that had a specific IQ cutoff, this value ranged from a low of 70 (or 2 SDs below the mean) to a high of 85 (or 1 SD below the mean). Only 4/26 studies had an IQ cutoff score below 80. Overall, the studies included in this systematic review mainly included participants who would meet the definition of SLI provided by the NIDCD: they had a language disorder that could not be explained by other factors such as hearing loss or cognitive/intellectual disabilities (NIDCD, 2019).

Table 1

References	Age	Language of Reading Test	Recruitment Source	Nonverbal Intelligence	Assessment Used to Determine Language Diagnosis	Assessment Used to Determine Reading Diagnosis	Comorbidity Rates
Adlof, S. M., Scoggins, J., Brazendale, A., Babb, S., & Petscher, Y. (2017). Identifying children at risk for language impairment or dyslexia with group-administered measures. Journal of Speech, Language, and Hearing Research, 60(12), 3507–3522. https://doi.org/10.1044/2017_JSLHR-L-16-0473	-Second grade -Mean age of 7.74 years -SD = .4 years	English	second grade classrooms	IQ Exclusion? NO (TONI-4) -"vast majority" of language impaired had normal nonverbal intelligence	GRADE LC (screening measure) CELF-4 (diagnostic/after screening) -1 SD below mean considered an LI	TOSWRF (screening measure) WRMT-III (diagnostic after screening) -1 SD below mean on Basic Skills cluster (cutoff of standard score of 85)	LI-only: 62 LI+D: 73
Alonzo, C. N., McIlraith, A. L., Catts, H. W., & Hogan, T. P. (2020). Predicting dyslexia in children with developmental language disorder. Journal of Speech, Language, and Hearing Research, 63(1), 151–162. . https://doi.org/10.1044/2019_JSLHR-L-18-0265	-5-7 year olds -Mean age of 6 -SD = .5 years	English	Kindergartn Classrooms	IQ Exclusion? YES (WPPSI) kids with a score below 70 were excluded	TOLD-2P AND narrative story task -at least two of 5 composite scores -1.25 SD or more below the mean -(info is from Tomblin et al., 1997)	WRMT-R (Word Identification subtest) -below 16th percentile considered Dyslexia	DLD-only: 117 DLD + DYS: 70
Bishop, D. V., & Adams, C. (1990). A prospective study of the relationship between specific language impairment, phonological disorders and reading retardation. Journal of child psychology and psychiatry, and allied disciplines, 31(7), 1027–1050. https://doi.org/10.1111/j.1469-7610.1990.tb00844.x	-mean of 8.4 -SD: 2.94 months	English	Asked professionals for referrals of children already diagnosed with SLI	IQ Exclusion? separate group -some children were identified with nonverbal developmental delays on the Leiter scale and were not excluded, but rather put into a separate "general delay" group (scored 2SD below mean) -WISC-R (age 8.5) -(picture completion and block design subtests) -Leiter scale	Good Outcome: -3-4 years old given diagnosis by trained SLP AND -have no score in the impaired range (below 3rd centile) and no more than one score below satisfactory (10th centile) on the following tests: MLU Naming Vocab Verbal Comp Action P Info Action P Gram Bus Story TROG BPVS Poor Outcome: -3-4 years old given diagnosis by trained SLP (ALL INFO PROVIDED BY BISHOP & EDMUNDSON, 1987)	SRR:A - reading accuracy -1.96 SDs below value predicted by summed picture completion and block design SRR:C - reading comprehension -1.96 SDs below value predicted by summed picture completion and block design Both: (met criteria for both of these) Backward Reader: reading scaled score below 71 on either accuracy or comprehension, but who did not fall into either SSR group USED NEALE ANALYSIS OF READING ABILITY	**Poor Outcome at 5 years old:** Both: 2 SRR-A: 2 SRR-C: 1 Backward Reader: 4 SLI-only: 28 **Good outcome at 5 years old:** SRR-C: 1 SLI-only: 28 **General Delay (delayed NVIQ):** Both: 3 SRR-C: 3 Backward Reader: 1 SLI-only: 9

Botting, N., Simkin, Z., & Conti-Ramsden, G. (2006). Associated reading skills in children with a history of specific language impairment (SLI). Reading and Writing: An Interdisciplinary Journal, 19(1), 77–98. https://doi.org/10.1007/s11145-005-4322-4	-10;1 to 11;10 -Mean age of 11 -SD: 5.3 months	English	language units (language based classrooms for children with SLI) attached to English mainstream schools identified by UK Charity ICAN (comprehensive list of all specialist language placements in UK) -only included kids that attended for at least 50% of the week	IQ Exclusion? NO (Raven's Coloured Matrices) (Conti-Ramsden et al., 1996)	-already given diagnosis (language unit)	**7 year old assessment:** -BAS-wr (word reading subtest) **11 year old assessment:** -WORD -Basic Reading -reading comprehension (scores below 85 considered below normal range)	**Reading Accuracy** -DLD-only: 65 -DLD+DYS: 134 **Reading Comprehension** -DLD-only: 40 -DLD+DYS: 156
Caccia, M., & Lorusso, M. L. (2020). The processing of rhythmic structures in music and prosody by children with developmental dyslexia and developmental language disorder. Developmental Science. https://doi.org/10.1111/desc.12981	-10-13 years old -mean age of 12.4 -SD: 1.23 years	English	selected from those diagnosed at the "institute" -unit of child psychopathology at institute	IQ Excluison? YES Coloured Progressive Matrices -score greater than or equal to 85	-sentence repetition (Ferrari, De Renzi, Faglioni, & Barbieri, 1981) -morphosyntactic comprehension and production (CoSiMo, described in Cantiani, Lorusso, Perego, Molteni, & Guasti, 2015) -direct to indirect speech transformation task -active to passive speech transformation task -free morphology task at least 1.5SD below mean on any of the 4 language tests	DDE-2 -word accuracy -word speed -nonword accuracy -nonword speed -text accuracy -text speed 2SD below mean in at least 2/6 tests	DLD-only: 8 DLD+DYS: 8
Catts, H. W., Adlof, S. M., Hogan, T. P., & Weismer, S. E. (2005). Are Specific Language Impairment and Dyslexia Distinct Disorders? Journal of Speech, Language, and Hearing Research, 48(6), 1378–1396. https://doi.org/10.1044/1092-4388(2005/096)	2nd graders, 4th graders, 8th graders	English	Child Language Research Center (population-based sample of children - tried to find out how these were recruited, but couldn't find the article [Tomblin et al., 2004])	IQ Exclusion? separate groups -tested in kindergarten and had to be within -1SD, but some children fell below this IQ cutoff at later ages and were not excluded in the "Low Achievement" Dyslexia definition -different definitions of Dyslexia depending on NVIQ Nonverbal IQ: -Kindergarten: Block Design and Picture Completion subtests of Wechsler Preschool and Primary Scale of Intelligence - Revised	five subtests of TOLD-2P 1. picture identification 2. oral vocabulary 3. grammatic understanding 4. grammatic comprehension 5. sentence imitation AND a narrative story task 5 composite scores based on these tests (vocabulary, grammar, narration, receptive, expressive) -fall below 1.25 SD on 2/5 composite scores	Word Identification and Word Attack subtests of WRMT-R (given in 2nd, 4th, and 8th grade) Used different definitions of Dyslexia so different cutoffs: 1. 1 SD below mean 2. 1 SD below mean AND within -1SD of mean IQ 3. 1 SD below predicted score (based on IQ) 4. 1SD below predicted score	**2nd grade:** -Low achievement (1 SD below mean): 33% -Low achievement + IQ cutoff: -full scale IQ (above -1SD): 18.9% -nonverbal IQ (above -1SD): 26.4 -IQ Discrepancy (-1SD from predicted) -full scale IQ: 17.9% -nonverbal IQ: 25.5%

				(nonverbal IQ) -Second Grade: WISC-III -Eighth Grade: Block Design and Picture Completion subtests of WISC-III Full Scale IQ: (2nd, 4th, 8th grade) PPVT-4 (+ scores on nonverbal IQ)		(based on IQ) and 1 SD below mean	-IQ Discrepancy + Low achievement (1SD for both) -full scale IQ: 17.9% -nonverbal IQ: 24.5% **4th grade:** Low achievement: 31.1% Low achievement + IQ cutoff: -full scale IQ: 19.8% -nonverbal IQ: 26.4% IQ Discrepancy: -full scale IQ: 17% -nonverbal IQ: 27.4% IQ Discrepancy + Low achievement: -full scale IQ: 17% -nonverbal IQ: 24.5% **8th grade:** Low achievement: 35.8% Low achievement + IQ cutoff: -full scale IQ: 20.8% -nonverbal IQ: 26.4% IQ Discrepancy: -full scale IQ: 18.8% -nonverbal IQ: 29.2% IQ Discrepancy + Low achievement: -full scale IQ: 17.9% -nonverbal IQ: 28.3%
Catts, H. W. (1993). The relationship between speech-language impairments and reading disabilities. *Journal of Speech and Hearing Research, 36*(5), 948-958. https://doi.org/10.1044/jshr.3605.948	1st and 2nd grade	English	All subjects had been referred for a speech-language evaluation in a school district	IQ Exclusion? YES WPPS -block design -picture completion "all participants displayed nonverbal intelligence within the normal range"	**Receptive:** -PPVT -Token Test of Children -Grammatical Understanding subtest of TOLD-2 **Expressive:** -Expressive One Word Picture Vocabulary Test -Structured Photographic Expressive Language Test-II	WRMT-R (1st and 2nd grade) -word identification -word attack GORT-R (2nd grade) 1SD below the mean of those in nominal-language group	"approximately 50% of the subjects in the SLI group were reading within normal limits in the first and second grades and a measure of reading comprehension in 2nd grade"

					-TOLD-2 -sentence imitation -grammatical closure **Articulation:** -Goldman Friscoe Test of Articulation Language impairment: 1SD below mean on at least 2/3 receptive measures and/or 2/3 expressive measures Aritculation: below average score on Goldman Friscoe Test -3 kids who were part of this group did not score below average, but were included in the study since they were enrolled in articulation therapy which was enough of a qualification to be included in the SLI group		AI subgroup (only articulation errors) performed at or above average levels of reading but was still included in the 50%
de Bree, E., Wijnen, F., & Gerrits, E. (2010). Non-word repetition and literacy in Dutch children at-risk of dyslexia and children with SLI: Results of the follow-up study. Dyslexia: An International Journal of Research and Practice, 16(1), 36–44. https://doi.org/10.1002/dys.395	-8 year olds -mean age of 8;6 -SD: 3.9 months	Dutch	speech therapists and schools for children with "severe speech and language difficulties"	IQ Exclusion? YES -not included in assessments, but all children with an SLI diagnosis had to have a nonverbal IQ >75	-given diagnosis by extensive assessments from speech language pathologists prior to study	-EMT -Klepel -AVI -SVS -O3C labeled "weak reader" if more than 1SD below control group's mean composite literacy score	SLI-only: 7 SLI+Dys: 8
Eicher, J. D., Powers, N. R., Miller, L. L., Akshoomoff, N., Amaral, D. G., Bloss, C. S., Libiger, O., Schork, N. J., Darst, B. F., Casey, B. J., Chang, L., Ernst, T., Frazier, J., Kaufmann, W. E., Keating, B., Kenet, T., Kennedy, D., Mostofsky, S., Murray, S. S., … Gruen, J. R. (2013). Genome-wide association study of shared components of reading disability and language impairment. Genes, Brain & Behavior, 12(8), 792–801. https://doi.org/10.1111/gbb.12085	9 years old (given diagnostic group at this age)	English	ALSPAC cohort (population-based birth cohort in Avon UK)	IQ Exclusion? YES (WISC-III) had to have IQ>75	-Auditory Analysis Test (phoneme deletion) (used to diagnose Dyslexia too) -WOLD - (verbal comprehension test) (age 8) -nonword repetition test given LI diagnosis if z-score less than or equal to -1 on 2/3 of the above tests	given dyslexia diagnosis if z-score less than or equal to -1 on 3/5 of the following tests: -phoneme deletion (age 7), same test given to determine LI -WORD - single word reading subtest (age 7) -single word reading (age 9) (Rust et al., 1993) -nonword reading (age 9) (Rust et al., 1993) -NARA-II - reading comprehension (age 9)	LI-only: 163 LI + RD: 174
Eisenmajer, N., Ross, N., & Pratt, C. (2005). Specificity and characteristics of learning disabilities. Journal of Child Psychology and Psychiatry, 46(10), 1108–1115.	-7-12 year olds -mean: 8;8 -SD: 1 year 3 months	English	children referred to a learning disabilities clinic for assessment of suspected	IQ Exclusion? separate group (WISC-III) -score above 80 meant placement in the SLI/LIRD group. If not then placed in GD group	-Total Language Score on CELF-R or CELF-3 below 85 (needed to score above 80 on IQ)	-WIAT reading subtest score below 85 -if below 85 on WIAT AND below 80 on WISC-III, put in GD group	SLI-only: 25 LIRD: 57 GD: 20

https://doi.org/10.1111/j.1469-7610.2004.00394.x			learning disability, all children had to be at least 1 year behind in reaeding, spelling, and/or mathematics.				
Fraser, J., Goswami, U., & Conti-Ramsden, G. (2010). Dyslexia and specific language impairment: The role of phonology and auditory processing. Scientific Studies of Reading, 14(1), 8–29. https://doi.org/10.1080/10888430903242068	-9-11 year olds -mean: 9.97 -SD: .47 years -	English	primary schools in northwest England referred children who were having reading and/or language difficulties -children with hearing difficulties and/or adhd were excluded from the study	IQ Exclusion? YES -all groups had an average IQ, although the study doesn't mention cutoff or individual scores WISC-III -block design -picture subtest	CELF-III -expressive tasks: -formulated sentences -sentence assembly -receptive tasks: -concepts and directions -semantic relations given LI diagnosis if standard score below 85 on at least 2 of these subtests	-BAS-II - single word reading -TOWRE - sight word efficiency subtest and decoding subtest given SRD diagnosis if score was less than 85 on at least 1/3 of the tests	SLI: 16 SLI + SRD: 21
Girbau-Massana, D., Garcia-Marti, G., Marti-Bonmati, L., & Schwartz, R. G. (2014). Gray–white matter and cerebrospinal fluid volume differences in children with Specific Language Impairment and/or Reading Disability. Neuropsychologia, 56, 90–100. https://doi.org/10.1016/j.neuropsychologia.2014.01.004	-8-10 year olds -SLI mean: 9.4, SLI+RD mean: 9.0 -SD: 8.55 months	Spanish	most children were recruited from two schools in a bilingual city in Spain (taught Spanish in schools but also can understand Catalan, a similar Romance language)	IQ Exclusion? YES TONI-2 -all children were in normal limits	-PPVT-III -TTFC-2 -WISC-IV (vocab subtest) -ITPA (four subtests) -auditory comprehension -auditory association -verbal expression -grammatical integration -CEG -non-word repetition task subset (Girbau & Schwartz, 2007a) given SLI diagnosis if: -1 SD below 2 of the subtests/tests AND less than or equal to 50% on the NRT subset	-PROLEC-R below -1 SD on at least 3/9 subtests	SLI: 4 SLI +RD: 6
Gray, S., Fox, A. B., Green, S., Alt, M., Hogan, T. P., Petscher, Y., & Cowan, N. (2019). Working memory profiles of children with dyslexia, developmental language disorder, or both. Journal of Speech, Language, and Hearing Research, 62(6), 1839–1858. https://doi.org/10.1044/2019_JSLHR-L-18-0148	-second graders -mean: 8.0 -SD: 5.66 months	English	-second grade children in schools in Arizona -recruited by screening in schools, parent packet asking if they wanted child to participate, and talked to	IQ Exclusion? YES Nonverbal Index of Kaufman Assessment Battery -score greater than or equal to 75	-CELF-4 score below 82	-TOWRE-2 score below 88	DLD: 9 DLD + DYS: 44

			SLPs for more children with DLD				
Hardiman, M. J., Hsu, H., & Bishop, D. V. M. (2013). Children with specific language impairment are not impaired in the acquisition and retention of Pavlovian delay and trace conditioning of the eyeblink response. Brain and Language, 127(3), 428–439. https://doi.org/10.1016/j.bandl.2013.08.001	-7-11 year olds -SLI mean: 8.7 SLI+RD: 9.0 -SLI-only SD: 1.4 months SLI+DYS SD: 11.7 months	English	recruited from special schools for children with language impairment or support units in mainstream schools	IQ Exclusion? YES Raven's Colored Picture Matrices -score greater than or equal to 85	-NEPSY (phonological processing) -BPVS-2 (receptive vocab) -ACE picture naming subtest (expressive vocab) -TROG-2 (receptive grammar) -ACE (syntactic formulation subtest) -ERNNI (comprehension) more than -1 SD below norm on at least 2/6 tests	TOWRE-2 (word reading and nonword reading) more than -1SD below norm on both tests	SLI: 17 SLI + RD: 22
Marshall, C. R., Harcourt-Brown, S., Ramus, F., & van der Lely, H. K. J. (2009). The link between prosody and language skills in children with specific language impairment (SLI) and/or dyslexia. International Journal of Language & Communication Disorders, 44(4), 466–488. https://doi.org/10.1080/13682820802591643	-10-15 year olds (recruited at ages 8-12 which is when clinical were formed) -SLI mean: 12.44 SLI+DYS: 12.75 -SLI-only SD: 1.15 years -SLI+DYS SD: 1.74 years ACTUAL AGES ARE ABOUT 24 MONTHS YOUNGER BECAUSE THEY WERE TESTED AT A DIFFERENT TIME	English	need statement of special educational need and attendance at a special school OR be in a unit for children with SLI or Dyslexia to be included in study	IQ Exclusion? YES RMP and block design subtest (BAS) -had to have minimum standard score of 80 on RMP and BAS (block design subtest) AND average combined minimum score of 85 [greater than -1SD below mean])	-TROG -BPVS -CELF (sentence repetition subtest) -TWF-2 standard score of 78 or below on at least 1/4 of these tests	WORD (single word reading subtest) standard score of 78 or below	SLI: 10 SLI+DYS: 28
McArthur, G., & Hogben, J. (2012). Poor auditory task scores in children with specific reading and language difficulties: Some poor scores are more equal than others. Scientific Studies of Reading, 16(1), 63–89.	6-12 years old -no mean age or sd	English	Recruited from Sydney schools, hospitals, and reading and language therapy clinics	IQ Exclusion? YES KBIT -all children had a nonverbal intelligence score of at least 80	CELF-4 (repeating sentences) NEPSY (repeating nonwords) TROG-2 BPVS-2 "score below the average range on at least 2/4" of these tests	Non-word reading (Edwards & Hogben, 1999) Irregular word reading (Edwards & Hogben, 1999) "4 kids scored below average on	SLI: 4 SLI+DYS: 21

https://doi.org/10.1080/10888438.2010.542526						both nonword and irregular word reading"	
McArthur, G. M., Hogben, J. H., Edwards, V. T., Heath, S. M., & Mengler, E. D. (2000). On the "specifics" of specific reading disability and specific language impairment. Journal of Child Psychology and Psychiatry, 41(7), 869–874. https://doi.org/10.1111/1469-7610.00674	-5-9 years old Study 1 mean: 8.5 Study 2 mean: 8.3 Study 3 mean: 7.8 -overall mean: 8.2 Study 1 SD: 6.67 months Study 2 SD: 7.09 months Study 3 SD: 8.53 months	English	Language Development centers that provide full time specialized teaching to children with SLI	IQ Exclusion? YES (WISC-R/WISC-3) -all children had a nonverbal intelligence score of at least 85	CELF-R need Total Language Score less than 85 to be allowed in SLI group	NARA-R (accuracy subtest) must be 1SD below average reading level	SLI: 50 SLI + DYS: 52
Przybylski, L., Bedoin, N., Krifi-Papoz, S., Herbillon, V., Roch, D., Léculier, L., Kotz, S. A., & Tillmann, B. (2013). Rhythmic auditory stimulation influences syntactic processing in children with developmental language disorders. Neuropsychology, 27(1), 121–131. https://doi.org/10.1037/a0031277	-6-12 years old -mean: 9 years 6 months -SD: 23 months	French	recruited from either a neuropediatric hospital clinic, special school for severe language and learning disorders, or a speech therapist office	IQ Exclusion? YES EDEI-R -"scores 2 sd inferior to the population mean"	-ELO -N-EEL (may include reading but I think it's just language...) -TCG -TVAP (vocab) -NEPSY "scores 2 sd inferior to the population mean"	-BALE (french) -(and possibly other tests as well) "scores 2 sd inferior to the population mean"	SLI: 8 SLI+DYS: 4
Ramus, F., Marshall, C. R., Rosen, S., & van der Lely, H. K. J. (2013). Phonological deficits in specific language impairment and developmental dyslexia: Towards a multidimensional model. Brain: A Journal of Neurology, 136(2), 630–645. https://doi.org/10.1093/brain/aws356	-8-12 years old -SLI only mean: 11.04 SLI+DYS mean: 11.22 -SLI only SD: 1.55 years SLI+DYS SD: 1.17 years	English	kids were "clinically referred"	IQ Exclusion? YES RSP and BAS-2 -had to have minimum standard score of 80 on both tests	-prior diagnosis -TROG-2 -BPVS-2 -CELF-3 (sentence repetition) -Test of Word Finding-2 standard score less than or equal to 78 on at least one of these tests	-WORD standard score less than or equal to 78	SLI: 13 SLI+DYS: 30
Rispens, J., & Been, P. (2007). Subject-verb agreement and phonological processing in developmental dyslexia and specific language impairment (SLI): A closer look. International Journal of Language & Communication Disorders, 42(3), 293–305. https://doi.org/10.1080/13682820600988777	-mean age of 101 months -SD: 3.8 months	English	-kids with SLI were selected by their SLPs and attended special schools for kids with SLI	IQ Exclusion? YES -all children had at least a 7 on WISC-R and all scored in the normal range for nonverbal IQ on both tests WISC-R + RAKIT	-had to be given the diagnosis previously by an SLP -did not give name of test but said they used "formal Dutch standardized language tests assessing expressive and receptive oral language skills, morphosyntactic skills and vocabulary" all children scored at least 2.5 sd	-RWT -PWT score lower than 7 (indicates poor performance)	SLI: 5 SLI+DYS: 6

					below the norm in at least 2 of these categories		
Robertson, E. K., Joanisse, M. F., Desroches, A. S., & Terry, A. (2013). Past-tense morphology and phonological deficits in children with dyslexia and children with language impairment. Journal of Learning Disabilities, 46(3), 230–240. https://doi.org/10.1177/0022219412449430	-8-11 years old -mean age: 9 years 4 months -NO SD	English	recruited from London, Ontario area schools	IQ Exclusion? YES WISC-3/4 -at least a 7 and no higher than 13	-TROG standard score of 83 or less on TROG	-WRMT-R (word identification) -percentile rank below 15	SLI: 9 SLI+DYS: 5
Share, D. L., & Leikin, M. (2004). Language impairment at school entry and later reading disability: Connections at lexical versus supralexical levels of reading. Scientific Studies of Reading, 8(1), 87–110. https://doi.org/10.1207/s1532799xssr0801_5	-5-7 year olds -mean: 6 (calculated) -phoneme segmentation group SD: .2 years general language group SD: .4 years phoneme+general SD: .3	English	kindergartn classrooms in Australia	IQ Exclusion? YES -not cutoff given, says that the children with below average nonverbal intelligence were "partialled out"	-phoneme segmentation -PPVT -Northwestern Syntax Screening Test -sentence repetition score below -1SD on phoneme segmentation OR/AND below -1SD on a standardized average score on the other 3 tests	-decontextualized word recognition -pseudoword reading -Neale Analysis of Reading Ability (passage comprehension, reading rate, reading accuracy) -1SD below standardized average score of all 5 tests -OR -1SD below decontextualized word recognition -OR -1SD contextualized word recognition (reading accuracy) -OR -1SD passage comprehension	SLI: 37 SLI+RD: 26 interestingly, only 2/30 in the phoneme segmentation and general language groups were classified as RD BUT 26/35 of the phoneme segmentation +general language (kids who struggled in both of these categories) were labeled as RD
Simpson, N. H., Addis, L., Brandler, W. M., Slonims, V., Clark, A., Watson, J., Scerri, T. S., Hennessy, E. R., Bolton, P. F., Conti-Ramsden, G., Fairfax, B. P., Knight, J. C., Stein, J., Talcott, J. B., O'Hare, A., Baird, G., Paracchini, S., Fisher, S. E., & Newbury, D. F. (2014). Increased prevalence of sex chromosome aneuploidies in specific language impairment and dyslexia. Developmental Medicine & Child Neurology, 56(4), 346–353. https://doi.org/10.1111/dmcn.12294	4-17 year olds	English	recruited from clinical and epidemiological cohorts through CLASP (Cambridge Language and Speech project), the Child Life and Health Department at the University of Edinburgh, Manchester Language study, and an independent case cohort from the Newcomen	IQ Exclusion? YES -have to have score above 80 on a nonverbal IQ test	CELF -1.5SD below that expected for age on expressive OR receptive	"reading or spelling scores more than 1SD below that expected for their age"	SLI: 78 SLI+DYS: 96

			Centre, London.				
Snowling, M. J., Bishop, D. V. M., & Stothard, S. E. (2000). Is preschool language impairment a risk factor for dyslexia in adolescence? Journal of Child Psychology and Psychiatry, 41(5), 587–600. https://doi.org/10.1111/1469-7610.00651	-15-16 year olds -mean: 15.6 -SD: .38 years	English	referrals from professionals (already diagnosed with SLI)	IQ Exclusion? YES -children identified at age 5 in Bishop and Adams (1980) in general delay group were not included in this study	already diagnosed (sample excluded any kids with poor nonverbal intelligence)	3 definitions of Dyslexia SRR:A - reading accuracy - WORD basic reading subtest score -1.96 SDs below value predicted by PIQ SRR:C - reading comprehension - WORD reading comprehension subtest score -1.96 SDs below value predicted by PIQ Both: (met criteria for both of these)	General categories SLI: 29 SLI+DYS: 27 SLI+DYS categories reading accuracy: 14 reading comprehension: 3 both: 10
Snowling, M. J., Duff, F. J., Nash, H. M., & Hulme, C. (2016). Language profiles and literacy outcomes of children with resolving, emerging, or persisting language impairments. Journal of Child Psychology and Psychiatry, 57(12), 1360–1369. https://doi.org/10.1111/jcpp.12497	7-8 years old -mean: resolving: 8;02 emerging: 7;09 persisting: 7;11 -SD: resolving: 3 months emerging: 5 months persisting: 5 months	English	part of Wellcome Language and Reading Project -recruited because of family risk of dyslexia or because parents thought the child had an SLI	IQ Exclusion? NO -WPPSI -WISC-4	**T1:** CELF -basic concepts subtest -expressive vocab subtest -sentence structure subtest TEGI -"fail" 2/4 of the tests (7 or below on CELF and failure of screener on TEGI) for clinical classification AND -1 SD below mean on composite language score (expressive vocab, sentence structure, and TEGI) **T3:** -1 SD below mean on composite language score (expressive vocab, sentence structure, and TEGI) **T3:** CELF -expressive vocab subtest -formulated sentences subtest TROG-II -1 SD below control mean on composite language score (expressive vocab, formulated sentences, TROG)	**T5:** SWRT GNWRT WIAT-II YARC (passage reading subtest) -1SD below control mean on composite score (tests listed above)	Total Denominator: 75 Resolving LI: 8% (calculation 1/12) Emerging: 48% (calculation: 10/21 Persisting: 41% (calculation: 17/42)
Spanoudis, G. C., Papadopoulos, T. C., & Spyrou, S. (2019). Specific language impairment and reading disability: Categorical distinction or continuum? Journal of Learning Disabilities, 52(1), 3–14.	-grades 2-4 -mean: 8.23 years -SD: 1.09 years	Greek	recruited from general and special education classrooms from five urban schools in	IQ Exclusion? YES CAS matrices -all groups scored "within average range"	-teacher completed 22-item checklist regarding reading and writing ability -had to be at or below the 20th percentile -WISC-3	-teacher completed 22-item checklist regarding reading and writing ability -had to be at or below the 20th percentile -Early Reading Skills Assessment	SLI: 13 SLI+DYS: 9

https://doi.org/10.1177/0022219418775111			Cyprus -no history of speech, attention, neurological, or hearing disorders		-(similarities AND vocabulary subtests) (assess expressive language) -TROG -PPVT-R (receptive language) 1SD below average age group mean on at least 1/4 of these tests"	Battery -(real word and nonword reading tasks) -Word Identification -Word Attack 1SD below average age group mean on two standardized word reading accuracy and fluency measures (real word and nonword reading)	
Stark, R., Bernstein, L., Condino, R., Bender, M., Tallal, P., & Catts, H. (1984). Four-year follow up study of language impaired children. *Annals of Dyslexia, 34,* 49-68. https://doi-org.pallas2.tcl.sc.edu/10.1007/BF02663613	-10;3	English	"all children were receiving language intervention before enrolled in project"	IQ Exclusion? YES WPPSI or WISC-R scale -between 85-125	-had to have an overall language age at least 12 months below their performance mental age or their chronological age, whichever was lower. -receptive language abilities had to be at least 6 months lower than their performance mental age -expressive language abilities had to be at least 12 months lower than their performance mental age	McGintie Reading Test -vocabulary subtest -comprehension subtest DYS: 2 grades below age level in vocab AND/OR comprehension mild DYS: 1 grade below age level in vocab AND/OR comprehension	LI-only: 3 LI+DYS: 23 LI+mild DYS: 3 2/3 of the LI-only group were from a group of 6 participants who did not meet the criteria for LI anymore. The third participant had a very mild LI. THIS WAS A FOLLOW UP STUDY AND IN THE INITIAL STUDY, ALL AVAILABLE 7-8 YEAR OLDS WERE READING IMPAIRED -no access to initial study
Talli, I., Sprenger-Charolles, L., & Stavrakaki, S. (2016). Specific language impairment and developmental dyslexia: What are the boundaries? Data from Greek children. Research in Developmental Disabilities, 49–50, 339–353. https://doi.org/10.1016/j.ridd.2015.12.014	-8-10 years old -mean: 9.26 years (111.07 months) -SD: 6.26 months	Greek	DD children were recruited from an interdisciplinary assessment in Greek hospitals. SLI children were recruited from SLPs who worked in speech therapy clinics All children had received language support	IQ Exclusion? YES "have IQ within the normal range (percentile based on French normative data from Raven (1981))"	(given diagnosis by SLP prior to study)	**Phonological Reading Skills:** -adaptation of Alouette test (reading level) -word level reading skills -one with 50 regular words -one with 50 pseudowords **Word Comprehension:** -Greek version of Ecosse (french test) (read a sentence, then found the picture that corresponded)	**Phonological word reading skills:** -Normal limits (SLI-only): 33.3% -1.0 SD below: 20% -1.5SD below: 46.7% **Reading Comprehension:** -Normal Limits (SLI-only): 20% -1.0: 0% -1.5: 80%

Vandewalle, E., Boets, B., Ghesquière, P., & Zink, I. (2010). Who is at risk for dyslexia? Phonological processing in five-to seven-year-old Dutch-speaking children with SLI. Scientific Studies of Reading, 14(1), 58–84. https://doi.org/10.1080/10888430903242035	-1st graders -5.3 years (63.8 months) -SD: 2.6 months	Dutch	recruited by open calls toward all speech and language therapists in the Dutch-speaking part of Belgium -all children started language therapy before the age of 4	IQ Exclusion? YES above 85 on one of these tests -WPPS -Snijders-Oomen Nietverbale Intelligentietest-R -Colombia Mental Maturity Scale	-Reynell Taalontwikkelingsschalen (subtest of Reynell Language Development Scales) - Taaltests voor Kinderen (subtest for Language Tests for Children) -Schlichting Test voor Taalproductie (subtest of Schlicting Test for Language Production had to score below 3rd percentile on at least one of these tests before beginning therapy (prior to recruitment). To ensure persistence, had to score below 10% on at least one of these at a second evaluation after age 4 (after recruitment)	-One minute word reading test (Brus & Voeten, 1973) -nonword reading test (van den Bos, Spelberg, Scheepstra, & de Vries, 1994) **(Boets, Wouters, van Wieringen, & Ghesquière, 2007)** -word reading accuracy test -nonword reading accuracy test -word reading speed test -nonword reading speed test -standardized spelling test (Dudard, 2006) -1SD on composite literacy score	SLI-only: 9 LD (literacy delayed): 9
Werfel, K. L., & Krimm, H. (2017). A preliminary comparison of reading subtypes in a clinical sample of children with specific language impairment. Journal of Speech, Language, and Hearing Research, 60(9), 2680–2686. https://doi.org/10.1044/2017_JSLHR-L-17-0059	-2nd to 4th graders -mean: 9 years 4 months -SD: 12 months	English	One of these two recruitment strategies: (a) targeted recruitment of children served under categories of speech/language impairment or reading impairment and (b) recruitment of children in general education classrooms of children identified in the previous process	IQ Exclusion? YES Toni-4 -score of 80 or above	CELF-4 -score below 85	TOWRE-2 -sight word efficiency -phonemic decoding efficiency WRMT-3 -passage comprehension **Dyslexia:** less than 85 on either subtest of the TOWRE-2 **AND** greater than or equal to 85 on the WRMT-3 passage comprehension subtest **Specific Reading Comprehension Deficit:** less than 85 on WRMT-3 passage comprehension subtest **AND** greater than or equal to 85 on either subtest of TOWRE-2 **Garden Variety Reading Impairment:** less than 85 on either subtest of the TOWRE-2 **AND** less than 85 on WRMT-3 passage comprehension subtest	SLI-only: 16% Garden Variety: 50% Specific Reading Comprehension: 9% Dyslexia: 25%
Wong, A. M.-Y., Ho, C. S.-H., Au, T. K.-F., Kidd, J. C., Ng, A. K.-H., Yip, L. P.-W., & Lam, C. C.-C. (2015). (Dis)connections between specific language impairment and dyslexia in Chinese. Reading and Writing: An Interdisciplinary Journal, 28(5), 699–719.	-6-7 year olds -mean: SLI-only: 7 years (84.66 months) SLI+DYS: 7.2 years (86.8	Mandarin	referred by SLP in local child assessment centers as having oral language impairment OR	IQ Exclusion? YES Raven's Standard Progressive Matrices -score 85 or above	HKCOLAS -Cantonese Grammar -Nominal Expressive Vocab -Textual Comprehension -Narrative Retell score 1.25 SD below the mean for age on two or more of the 6 subtests	HKT-P 7 or lower on literacy composite	SLI-only: 19 SLI+Dys: 25

https://doi.org/10.1007/s11145-015-9546-3	months) -SD: SLI-only SD: 3.21 months SLI+DYS SD: 4.17 months		failed the screening.				
Wong, A. M.-Y., Kidd, J. C., Ho, C. S.-H., & Au, T. K.-F. (2010). Characterizing the overlap between SLI and dyslexia in Chinese: The role of phonology and beyond. Scientific Studies of Reading, 14(1), 30–57. https://doi.org/10.1080/10888430903242043	-6-11 years old -mean: SLI-only: 9 (106.29 months) SLI+DYS: 9 (106.54 months) -SD: SLI only: 5.65 months SLI+DYS: 16.26 months	Mandarin	mentions 13 children recruited from a child assessment center, but this is the only info provided on recruitment	IQ Exclusion? YES HKWI -all scored in normal age limits on full scale Raven's -15/17 scored no lower than 1 SD below mean. 2/17 scored only 2-3 points below 1SD and were included	HKCOLAS (all 6 subtests) score 1.25 SD below mean for age on at least 2/6 subtests	HKT-P -rapid digit naming -phonological awareness -working memory -orthographic skills 1SD or more below mean on literacy composite (HKT-P composite) AND at least 1/4 subtests	SLI-only: 7 SLI+DYs: 13

As shown in Table 2, comorbidity rates across all studies and methods of classifying reading impairments ranged from a low of 8.5% (Bishop & Adams, 1990), to a high of 90% (Stark et al., 1984).

Recruitment method. Within caseload studies, comorbidity rates ranged from 8.5%-90% The majority of studies that recruited from caseloads (17/22, (77%)) had a comorbidity rate greater than or equal to 50%. Additionally, 7/22 caseload studies (32%) had a rate greater than 65%. In comparison, the comorbidity rate ranged from 31.1%-60% for community-recruited samples, and 6/9 of the rates derived from community recruited samples were below 50%. (Note that Catts et al. (2005) provided multiple rates depending on the age at which the participants were tested.) Although there is overlap in rates across both recruitment methods, the comorbidity tended to be higher for studies that recruited from caseloads than for studies that used community samples. For the two studies with mixed recruitment methods, the rates were variable with one study reporting a rate of 83% and the other a rate of 41%.

Age. Two studies (2/32) evaluated children between 5-6.99 years and had comorbidity rates of 41% and 50%. The 7-8.99 age range was the most commonly assessed age group (15/32 studies, (47%)) with comorbidity rates spanning from 8.5%-83%. The median comorbidity rate for this group of studies was 53% and the majority of rates reported in this age group (11/15, (73%)) had comorbidity rates greater than or equal to 50%. For any study that provided multiple rates of comorbidity across different types of reading assessments, the average of these rates was used to determine the median. Within the 9-10.99 age group (9/32 studies, (28%)), the comorbidity rate ranged from 31.1%-90% and had a median of 57%. As before, rates from studies reporting multiple rates were averaged to determine the median. Finally, in all studies that reported comorbidity rates for children with a mean age of 11 years or older (6/32, (19%)),

the comorbidity rates ranged from 18% to 80% and had a median of 60%. For studies that provided multiple rates for different reading measures, the average of these rates was used to determine the median. Note that Catts et al. (2005) provided a rate for the 7-8.99, 9-10.99, and 11+ age groups.

Overall, higher maximum comorbidity rates were observed for older ages, but there was substantial overlap in rates across age groups. Additionally, there were fewer studies of children in the youngest and oldest age groups, which limits the ability to make strong comparisons.

Type of reading impairment. Most studies reported reading impairment status as determined by word reading assessments (23/32, (78%)); however 5/32 studies (16%) reported reading impairment as determined by reading comprehension, and 12/32 (37.5%) determined reading impairment by any combination of word reading, spelling, and/or reading comprehension. Note that some studies reported rates of reading impairment by more than one method.

Within studies that reported comorbidity rates determined by word reading assessment, comorbidity ranged between 8.5%-85%. Within studies that reported comorbidity rates determined by reading comprehension assessments, comorbidity ranged between 12%-80%. Finally, within studies that used some combination of word-reading, spelling, and/or comprehension measures to determine reading impairment status, the comorbidity rate ranged from 12%-90%.

Type of Reading Impairment by Recruitment Method. Most of the studies in this review recruited children with DLD from caseloads and determined reading impairment status based on word reading tests (16/32, (50%)). The comorbidity rate for this set of studies ranged from 8.5%-85% and all but 2 studies had rates above or equal to 50%. The median rate of

comorbidity in this group was 56.5%. In comparison, four studies (with 6 reported comorbidity rates) recruited from community samples, and these studies reported rates of word reading impairment from 31.1%-54% and had a median of 35.9%. (Note that Catts et al. (2005) had 3 rates included in this median.) Only one study that recruited from a community sample had a rate greater than 50% (Adlof et al., 2017). Therefore, even when looking specifically at word reading as a factor in comorbidity rates, caseload studies still tended to have greater comorbidity rates than community samples.

All five studies that utilized reading comprehension to determine comorbidity rates were caseload samples. The range of comorbidity rates for these studies was 12%-80% and had a median of 59%. Note that the two studies with rates of comorbidity below the median were from the same sample (Bishop & Adams, [1990] and Snowling et al., [2000]), and used stricter criteria for determination of reading impairment (i.e., IQ discrepancy model, -1.96 SD below child's PIQ) than the other studies. Overall, the median comorbidity rates for caseloads were similar whether reading impairment was determined by word reading measures (median = 56.5%) or reading comprehension measures (median = 59%).

The comorbidity rates associated with any combination of word reading, spelling, and/or word comprehension, ranged from 12% to 90%. Within caseload studies, 9/22 (41%) provided a rate determined by any combination of word reading, spelling, and/or word comprehension and ranged from 12% to 90%. This group of studies had a median of 50%. Additionally, some community samples (3/7) provided rates for any combination of word reading, spelling, and/or word comprehension with values ranging from 41% to 60% and had a median of 52%. Therefore, the median comorbidity rates for caseloads were similar whether reading impairment was determined by word reading measures (median = 56.5%), reading comprehension measures

(median = 59%) or for word reading, spelling, and/or word comprehension (median = 50%), although this last category was slightly lower than the first two. Additionally, the median comorbidity rate for community samples utilizing word reading measures (median = 35.9%) was less than the median comorbidity rate for community samples utilizing word reading, spelling, and/or word comprehension measures (median = 52%). However, there was a lot of overlap in comorbidity rates across studies and a very small number of community samples which makes it difficult to make accurate comparisons.

Table 2

	Mean Age	STUDY NAME	N of children with SLI	Study criteria for reading impairment	Percent of children with SLI who have word-level reading impairment	Percent of children with SLI who have reading comprehension impairment	Percent of children with SLI who have word-level/spelling and/or reading comprehension impairment
Caseload							
	5-6.99						
		Vandewalle et al. (2010)	18	-One minute word reading test (Brus & Voeten, 1973) -nonword reading test (van den Bos, Spelberg, Scheepstra, & de Vries, 1994) **(Boets, Wouters, van Wieringen, & Ghesquière, 2007)-> for all tests below** -word reading accuracy test -nonword reading accuracy test -word reading speed test -nonword reading speed test -standardized spelling test 1SD on composite literacy score	50%		
	7-8.99						
		Bishop & Adams (1990)[a]	Poor outcome: 37 Good outcome: 29 General Delay: 16 Total: 82	Used NEALE analysis of reading ability SRR:A - reading accuracy -1.96 SDs below value predicted by summed picture completion and block design SRR:C - reading comprehension -1.96 SDs below value predicted by summed picture completion and block design	Poor: 11% Good: 0% Delay: 19% Total: 8.5%	Poor: 8% Good: 3% Delay: 38% Total: 12%	Poor: 16% Good: 0% Delay: 25% Total: 12%

				Both: (met criteria for both of these)			
		Catts (1993)[b]	56	WRMT-R (1st and 2nd grade) -word identification -word attack GORT-R (2nd grade) "SLI group demonstrated lower reading achievement skills than the normal group" "50% were reading within normal limits in the first and second grade" 1SD below the mean of those in nominal-language group			50%
		de Bree et al. (2010)	15	-EMT -Klepel -AVI -SVS -O3C reading impaired if more than 1SD below control group's mean composite literacy score	53%		
		Eisenmajer et al. (2005)	w/out GD: 82 Total: 102	-WIAT (reading subtest) score below 85 If below 85 on WIAT AND below 80 on WISC-III, put in GD group			w/out GD: 70% Total: 75%
		Hardiman et al. (2013)[c]	39	-TOWRE-2 (word reading and nonword reading) more than 1SD below norm on both tests	56%		

		McArthur et al. (2000)	102	-NARA-R (accuracy subtest) must be 1SD below average reading level	51%		
		Rispens & Been (2007)	11	-RWT and PWT score below 7 on both	55%		
		Snowling et al. (2016)	Resolving: 12 Emerging: 21 Persisting: 42 Total: 75	-SWRT -GNWRT -WIAT-II -YARC (passage reading subtest) 1 SD below control mean on composite score			Resolving LI: 8% Emerging: 48% Persisting: 41% Total: 37%
		Wong et al. (2015)[d]	44	-HKT-P 7 or lower on literacy composite	57%		
	9-10.99						
		Fraser et al. (2010)	37	-BAS-II (single word reading) -TOWRE (sight word efficiency and decoding subtests) score less than 85 on 1/3 of the tests	57%		
		Przybylski et al. (2013)	12	-BALE (and possibly other tests as well) scores 2SD below population mean			33%

		Talli et al. (2016)[e]	15	**Phonological Reading Skills:** -adaptation of Alouette test (reading level) -word level reading skills -one with 50 regular words -one with 50 pseudowords 1 SD below normal limits **Word Comprehension:** -Greek version of Ecosse (french test) (read a sentence, then found the picture that corresponded) 1 SD below normal limits	Total: 66.7%	80%	
		Werfel & Krimm (2017)	32	TOWRE-2 -sight word efficiency -phonemic decoding efficiency WRMT-3 -passage comprehension **Dyslexia:** less than 85 on either subtest of the TOWRE-2 **AND** greater than or equal to 85 on the WRMT-3 passage comprehension subtest **Specific Reading Comprehension Deficit:** less than 85 on WRMT-3 passage comprehension subtest **AND** greater than or equal to 85 on either subtest of TOWRE-2 **Garden Variety Reading Impairment:** less than 85 on either subtest of the TOWRE-2 **AND** less than 85 on WRMT-3 passage comprehension subtest	75%	59%	50%

		Stark et al. (1984)	29	McGintie Reading Test -vocabulary subtest -comprehension subtest DYS: at least 2 grades below age level in vocab AND/OR comprehension mild DYS: ONLY 1 grade below age level in vocab AND/OR comprehension			90%
	11+"						
		Botting et al. (2006)	Word Reading: 199 Comprehension: 196	-WORD -Basic Reading -reading comprehension Below 85 on either reading or comprehension tests	67%	80%	
		Caccia & Lorusso(2020)	16	-DDE-2 -word accuracy -word speed -nonword accuracy -nonword speed -text accuracy -text speed 2SD below mean in at least 2/6 tests	50%		
		Marshall et al. (2009)	38	-WORD (single word reading subtest) standard score of 78 or below	74%		
		Ramus et al. (2013)	43	-WORD standard score of 78 or below	70%		

		Snowling et al. (2000)[a]	56	-WORD -basic reading -reading comprehension score -1.96 SDs below value predicted by PIQ on EITHER/BOTH subtests	43%	23%	18%
	Unknown						
	Between the ages of 6 and 12	Mcarthur et al. (2012)	25	Non-word reading (Edwards & Hogben, 1999) Irregular word reading (Edwards & Hogben, 1999) "4 kids scored below average on both nonword and irregular word reading"	85%		
	Between the ages of 4 and 17	Simpson et al. (2014)	174	"reading or spelling scores more than 1SD below that expected for their age"			55%
Community Sample							
	5-6.99						
		Share & Leikin (2004)[f]	63	-decontextualized word recognition -pseudoword reading -Neale Analysis of Reading Ability (passage comprehension, reading rate, reading accuracy) 1SD below standardized average score of all 5 tests OR -1SD below decontextualized word recognition OR -1SD contextualized word recognition (reading accuracy)			41%

				OR -1SD passage comprehension			
	7-8.99						
		Adlof et al.(2017)	135	-WRMT-III 1 SD below mean on Basic Skills cluster (cutoff of standard score of 85)	54%		
		Alonzo et al. (2020)	187	-WRMT-R (Word Identification subtest) must be below 16th percentile	37%		
		Catts (2005)$_g$	106	-WRMT-R -word identification -word attack below 1SD of mean	33%		
	9-10.99						
		Catts (2005)$_g$	106	-WRMT-R -word identification -word attack below 1SD of mean	31.1%		

		Eicher et al. (2013)	337	-WORD - reading subtest (single word reading) (age 7) -single-word reading AND nonword reading (Rust et al. 1993) (age 9) -NARA-II (reading comprehension) (age 9) given dyslexia diagnosis if z-score less than or equal to -1 on 3/5 of the following tests: phoneme deletion (age 7), single word reading (age 7), single word reading (age 9), nonword reading (age 9), reading comprehension (age 9)			52%
		Girbau-Massana (2014)	10	-PROLEC-R below -1 SD on at least 3/9 subtests			60%
		Robertson et al. (2013)	14	-WRMT-R (word identification) percentile rank below 15	36%		
	11+"						
		Catts (2005)[g]	106	-WRMT-R -word identification -word attack below 1SD of mean	35.8%		
MIX							
	7-8.99						
		Gray (2019)	53	-TOWRE-2 score below 88	83%		

		Spanoudis et al. (2019)	22	-teacher completed 22-item checklist regarding reading and writing ability -had to be at or below the 20th percentile -Early Reading Skills Assessment Battery -(real word and nonword reading tasks) -Word Identification -Word Attack 1SD below average age group mean on two standardized word reading accuracy and fluency measures (real word and nonword reading)	41%		
Unknown							
	7-8.99						
		Wong et al. (2010)[h]	20	-HKT-P literacy subtest AND 4 cognitive subtests: -rapid digit naming -phonological awareness -working memory -orthographic skills 1SD or more below mean on literacy composite (HKT-P composite) AND at least 1/4 cognitive subtests	65%		

Notes: [a] Bishop & Adams (1984) is the same participant sample as Snowling et al. (2000), but Snowling et al. (2000) tested the children at 15 years old and did not include any of the children in Bishop & Adams (1984) "General Delay" group. [b] Catts (1993) included 15 subjects with just articulation issues in its LI group and none of these children had a reading impairment. [c] Hardiman et al. (2013) provided the mean age for their SLI-only and their SLI+reading impairment (RI) groups separately. However, the

mean age for their SLI-only group was 8.7 and for their SLI+RI was 9.0. Because the average of these two groups was 8.85, we included it in the 7-8.99 age category. [d] Wong et al. (2015) was classified as a caseload because the majority of children were recruited this way, however a few children intended for the control group failed the screening and were included in the DLD/SLI group. [e] In Talli et al. (2016), 80% of children with DLD/SLI scored **2SD** below normal limits on the reading comprehension test. [f] Share & Leikin (2004) categorized LI children into different categories and found that only 2/30 children who only struggled with phoneme segmentation or general language had a reading impairment whereas 26/35 children who struggled with phoneme segmentation AND general language had reading impairment. [g] Catts et al. (2005) was a longitudinal study that looked at comorbidity rates overtime in 3 different grades: 2nd, 4th, and 8th. As a result, this study is listed in 3 different age categories. Additionally, Catts et al. (2005) did not have a mean age so each rate was placed in the age group generally corresponding to the grade referenced in the paper. This study also provided multiple rates of comorbidity depending on how reading impairment was defined based on a child's NVIQ. In this chart, we only included rates that did not have an IQ cutoff or utilize an IQ discrepancy model. Lastly, this study had participant overlap with Alonzo et al. (2020), but it tested the children at two different ages. [h] Wong et al. (2010) stated that they recruited 13 children from a "child assessment center", but were not clear on what this means and if the children had a prior language impairment diagnosis.

Discussion

Often, DLD/SLI and Dyslexia are studied separately in research, but because of the co-occurrence often observed in both disorders, the relationship between DLD/SLI and Dyslexia has been debated. As of recently, the prominent theory (put forward by Catts et al., 2005) is that the reading problems observed in some children with DLD/SLI are the result of concomitant Dyslexia. Understanding the influence of Dyslexia on children with DLD/SLI is important to consider and may impact the conclusions drawn about DLD/SLI. However, the reported rates of comorbidity in research vary greatly and this variance may be the result of methodological differences.

In this systematic review, we conducted a search of PsycInfo and coded articles that matched our inclusion and exclusion criteria to examine the effect that different study factors have on reported comorbidity rates. We initially started with 286 articles that we eventually filtered down to 32 and we specifically looked at how recruitment method, mean age, and type of reading assessment affected reported comorbidity. We hypothesized that caseload studies would have higher reported comorbidity rates because children with comorbid DLD/SLI and Dyslexia would be more likely to have severe deficits and seek services for their language issues. Additionally, because research has shown that children with DLD/SLI universally have deficits in reading comprehension, we theorized that higher comorbidity rates would be observed in studies with older children and in studies that used comprehension as a method of determining reading impairment.

After filtering and coding the articles, we found that caseload samples generally (but not always) had higher comorbidity rates than community samples. The majority of caseload studies had a rate greater than or equal to 50%, whereas the majority of community sample rates had

rates below 50%. This was also observed when we examined word-reading assessment rates in caseload vs. community samples and the median for word reading rates in caseloads was 56.5% and the median for word reading rates in community samples was 35.9%. Overall, caseload samples generally had higher comorbidity rates than community samples, but there was a lot of overlap with both groups displaying a large range in comorbidity rates, making it difficult to conclusively make this statement.

Additionally, we found that generally, as age increased, comorbidity rates also increased. The medians across all age groups grew consistently, starting with 45.5%, then 53%, then 57%, and finally 60%. Although this trend in the medians seems to easily fit into the idea that comorbidity rates increase with age, there was substantial overlap in rates across all age groups and there were not that many studies available for the youngest and oldest age groups. Therefore, even though, generally, comorbidity rates increased with age, it is hard to make strong comparisons across groups.

Lastly, comorbidity rates determined by word reading generally tended to have lower rates of comorbidity than those determined by reading comprehension in caseload studies. Word reading rates had a median of 56.5% whereas reading comprehension rates had a median of 59%. However, although this was generally observed in the results, the difference in these two values is slight and there were only 5 comprehension studies that were all recruited by the same method. Additionally, there was also overlap in comorbidity rates across both word reading and comprehension studies, all of which makes it difficult to generalize and accurately confirm this finding.

This study did have some limitations, specifically in terms of the number of studies that looked at reading comprehension rates (5/32) and the number of studies in the 5-6.99 (2/32) and

11+ (6/32) age groups. The paucity of information for these categories makes it difficult to fully compare comorbidity rates across other study groups and limits the generalizability of our findings.

A future direction of study might be a quantitative meta-analysis to better estimate the influence of these variables (recruitment method, mean age, etc.) on comorbidity rates. Our study did not take into account sample size when drawing up comparisons which is something that could be very influential on our findings and that a meta-analysis would be able to factor in.

Overall, based on these conclusions and considerations, we determined that comorbidity rates are variable and may be influenced by methodological decisions regarding recruitment and assessment methods. These decisions might lead some studies to have higher or lower rates of comorbidity which then may influence the conclusions drawn related to DLD/SLI. In a review conducted by McGregor (2020), the researcher concluded that children with DLD/SLI are common, but under-diagnosed and under-researched. Consequently, when research does not accurately portray this population of children, the results can be detrimental. Accurate information regarding this disorder is necessary and it is therefore important to factor in how methodology may influence the results provided for children with DLD/SLI so that a more precise profile is achieved and accounted for when studying and working with these children.

Additionally, these results emphasize the importance of acknowledging the co-occurrence of DLD and reading impairment. While the comorbidity rates themselves varied, the presence of comorbidity in each sample is important to note as it provides evidence that these two disorders commonly co-occur. As was mentioned previously, DLD is common but under-diagnosed and as a result, these children are less likely to receive the support that they need for both oral language *and* written language skills.

Our hope is that this study will emphasize the importance of providing support for both oral language and written language skills in children with DLD/SLI and also encourage researchers and SLPs/educators to consider the influence that methodological differences might have in determining comorbidity and the DLD/SLI profile.

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