The Effect of Preschool Vocabulary and Grammar on Early Reading Comprehension and Word Reading: A Systematic Review and Meta-analysis

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Abstract

The oral language skills of vocabulary and grammar are associated with early reading ability, but how they relate to different aspects of reading – comprehension, word reading, and pseudoword reading – has not been systematically compared. A meta-analysis of 72 longitudinal studies (comprising 499 correlations from 23,387 children) examined the predictive relationship between vocabulary and grammar in preschool and reading comprehension, word reading, and pseudoword reading in children at the start of formal schooling. Preschool vocabulary and grammar each had significant, moderate effects on all aspects of early reading. This relationship was not moderated by the nature of the preschool oral language assessment (receptive vs expressive; complexity of response), nor by the time interval between preschool measures of oral language and school-aged measures of early reading. The age of the onset of formal schooling (used as a proxy for the start of formal reading instruction) moderated the size of the effect between preschool vocabulary and school-age word reading, revealing a greater impact for earlier formal schooling. Preschool vocabulary and grammar thus has a direct influence on all aspects of early reading, highlighting the benefit of early oral language support, particularly when reading instruction begins early in children's formal schooling.

Keywords*:* Oral language; Vocabulary; Grammar; Word reading; Pseudoword reading; Reading comprehension; Beginning reading.

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Highlights

(1) Oral language assessed before formal reading instruction influences early reading.

(2) Associations from oral vocabulary and grammar to early reading are similar in size.

(3) Each predicts reading comprehension, word reading, and pseudoword reading.

(4) Oral language skills are more important for those with earlier school starting age.

The Effect of Preschool Oral Vocabulary and Grammar on Early Reading Comprehension and Word Reading: A Systematic Review and Meta-analysis

1. Introduction

It has long been known that preschool oral language predicts early reading attainment (Catts et al., 1999; Scarborough, 1990). A popular framework to examine these relations is the simple view of reading (Hoover & Gough, 1990; Hoover & Tunmer, 2018). The simple view of reading proposes that reading comprehension is the product of two cognitive components, word reading and listening comprehension. Each component has conceptually separable predictors. Specifically, code-related knowledge and skills, such as print knowledge and phonological awareness, directly support word reading, and oral language skills, such as vocabulary and grammar, directly support listening comprehension. Although the simple view framework has been validated by empirical research (Kendeou et al., 2009; Language and Reading Research Consortium (LARRC) & Chiu, 2018; Storch & Whitehurst, 2002), correlations between measures of word reading and listening comprehension, as well as their predictors in measures of preschool language skills, were also observed in these studies. Such statistical associations indicate that listening comprehension, and its correlates, may not only be related to reading comprehension, but also implicated in word reading. Thus, there may be support for theoretical models that propose a role for oral language, in addition to code-related skills, for word reading development (Harm & Seidenberg, 2004; Metsala & Walley, 1998).

This research background informed the primary objective of this systematic review and meta-analysis to determine the size of the effect of preschool oral language (specifically vocabulary and grammar) on three different indicators of early reading ability: reading

comprehension, word reading, and pseudoword reading. We first review the established relationship between these aspects of oral language and reading comprehension, and then consider their link with word reading. The reported size of these relationships is highly variable across studies, so we also consider possible influences (moderators) that may affect the prediction of both reading comprehension and word reading from preschool oral language.

1.1. The relationship between preschool oral language and school-age reading comprehension

Our focus is the influence of preschool oral language on early reading, examining the influence of vocabulary knowledge and grammar, referred to as lower-level or foundational language skills for discourse (prose) comprehension (Kim, 2015; Lepola et al., 2012). Narrative skills are another aspect of oral language that predict reading comprehension in the early years (Kendeou et al., 2009; Silva & Cain, 2015), but were not considered in this study. The theoretical basis for the association between oral vocabulary and grammar and reading comprehension is clear: Comprehension of written prose involves the retrieval of precise context-specific word meanings, syntactic parsing to extract sentence meaning, and integration between the information in different sentences with a reader's general knowledge to construct a coherent representation of the text's meaning (Kintsch, 1998). The predictive roles of both oral vocabulary and grammar for reading comprehension are well established: Each explains unique variance in concurrent reading comprehension in young readers (Language and Reading Research Consortium (LARRC) & Logan, 2017); they are associated with reading comprehension longitudinally (Kendeou et al., 2009; LARRC & Chiu, 2018; Storch & Whitehurst, 2002); they are weak in children with reading comprehension difficulties (Nation et al., 2004); and

interventions in oral language that include both vocabulary and grammar, as well as listening and narrative skills, are associated with enhanced reading comprehension outcomes (Fricke et al., 2013).

However, there is considerable variation amongst studies in the strength and nature of the association between early oral language and later reading comprehension. Whilst some report a direct influence of preschool oral language on reading comprehension (Caravolas et al., 2019; Roth et al., 2002), others do not (Fricke et al., 2016). A previous meta-analysis that tested the fit of the simple view to early reading revealed a sizeable range of correlations between early oral language to later reading comprehension from .13 to .67 (Hjetland et al., 2020). Such variation may arise due the differences that exist between reading comprehension assessments, which tap into a range of language and cognitive skills (Garcia & Cain, 2014; Keenan & Meenan, 2014). Such variation may also be due to the aspects of oral language considered in different studies. Whilst some have included vocabulary as the single indicator of oral language (Aarnoutse et al., 2005), others also included grammar (Roth et al., 2002), but not all studies have investigated their independent contributions (Fricke et al., 2016; LARRC & Chiu, 2018).

An advantage of using a composite measure or single latent construct to represent oral language is to provide a comprehensive or broad assessment of oral language and to mitigate measurement error. However, this approach does not allow researchers to examine potentially unique individual influences of vocabulary and grammar. Where studies have investigated the contribution of vocabulary and grammar separately, some find a slightly stronger association between grammar and early reading comprehension both concurrently (LARRC & Logan, 2017)

and longitudinally (Muter et al., 2004), although not all find this differential prediction (e.g., (Roth et al., 2002). Thus, we examined the separate influence of vocabulary and grammar on later reading comprehension to establish whether or not they differ in predictive strength.

1.2. The relationship between oral language and word reading

Both oral vocabulary and grammar are associated with word reading scores, despite the proposed separation of oral language skills from word reading in the simple view of reading. Code-related skills such as phonemic awareness that are strongly predictive of word reading are significantly associated with oral vocabulary in beginner readers (Ouellette & Haley, 2013). Furthermore, several studies report a positive and significant association between vocabulary knowledge and word reading in young readers, in addition to the predictive role of decoding skills (Ouellette, 2006; Ouellette & Beers, 2010; Ricketts et al., 2007). However, the influence of vocabulary in these studies was specific to irregular or exception words, such as 'build' and 'freak', for which mapping letters to sounds is not sufficient to ensure accurate pronunciation. Vocabulary did not influence the ability to read regularly spelled words and pseudowords (letter strings that follow the phonotactic constraints of the language, but which carry no meaning). On the other hand, Ricketts et al. (2016) did find an influence of vocabulary knowledge on both regular and irregular word reading in young children.

The influence of vocabulary on word reading ability in these studies has been explained through computational models of reading (see Monaghan, 2023, for a review). There are two theoretical models that specify the computational mechanisms relating early oral language skills and reading development. First, the connectionist triangle model provides an implemented framework where learning to read involves learning to map among written,

spoken, and meaning representations of words (Harm & Seidenberg, 2004), and which predicts a specific relationship between vocabulary and irregular (or exception) word reading. As the model learns to recognize written words, there is an initial focus by the model on establishing connections between orthography and phonology (the phonological pathway) that broadens to include connections via semantics (the semantic pathway) (Chang et al., 2019). This change in resource allocation enables accurate reading of regular (or consistent) words by applying learned regularities between orthography and phonology and, critically, also enables accurate reading of words that are irregular, for which reliance on letter-sound mappings alone may result in mispronunciations and where the semantic pathway contributes more to processing. Thus, the role of oral vocabulary skills for irregular words, in addition to regular words, can be explained by this greater involvement of semantics in reading.

The triangle model focuses on the skills that predict word reading ability and its development during reading instruction and engagement with print. Another account, the lexical restructuring hypothesis, provides a mechanism for the relation between oral language skills that develop prior to reading instruction and early word reading (Metsala & Walley, 1998). As a child's oral lexicon develops, more fine-grained representation of the phonological codes of words is required to differentiate similar sounding words, such as 'cat' and 'cot'. This requires restructuring of representations from the level of the syllable to the phoneme. In this way, pre-literacy vocabulary is thought to influence early word reading indirectly through increasingly precise and fine-grained specification of phonological codes. This account is also consistent with the triangle model of reading, where greater fidelity of phonological

representations can emerge as a consequence of more experience with oral vocabulary (e.g., Chang et al., 2019; Harm & Seidenberg, 1999).

There has been less research examining the role of early grammatical skills on word reading, compared with the numerous studies on the role of vocabulary. Concurrent measures of grammar and word reading are directly related in beginner readers (Kim, 2015) indicating an early influence of grammar. Longitudinally, morphosyntax measured in kindergarten is uniquely predictive of pseudoword, but not real word, reading two years later (Roth et al., 2002). Thus, as for vocabulary, there is evidence that grammar is associated with different processes for word reading. In the triangle model framework, the indirect semantic pathway is less active for pseudowords than words (Harm & Seidenberg, 2004), and so oral grammar, independent of oral vocabulary, may then be observed as influencing the direct orthography to phonology pathway, where decoding of letters to sounds occurs.

In sum, the research base and proposed theoretical pathways between preschool oral vocabulary and grammar and word reading provide a strong motivation to distinguish and determine the relative strengths of these associations. Our study makes a unique contribution by examining the individual influences of vocabulary and grammar on assessments of word reading in general. With regard to vocabulary, there is a suggestion that vocabulary may be related to word reading ability through its relation to the quality of both semantic and phonological representations of words. With regard to grammar, the mechanisms posited to support word reading are related to morphosyntax and, therefore, one would assume these are specific to meaning. However, studies of preschoolers report a relationship with only pseudowords (Roth et al., 2002), suggesting that morphosyntactic coding may instead be

related to phonological decoding. Our study is unique by examining whether different aspects of preschool oral language (vocabulary and grammar) support word reading in general, or specifically word reading through semantic or phonological support. We do so by examining whether the strength of the relationship differed by type of stimuli (real vs pseudowords).

1.3. The potential influence of the modality of preschool oral language measures (receptive vs expressive) on the strength of the association between preschool oral language and early reading

Oral language is multifaceted and, consequently, assessment varies. Measures can tap receptive or expressive language (comprehension tasks such as picture identification and production tasks such as sentence recall, respectively), and/or provide different types of stimuli (pictures, sentences, short narratives to recall), and/or require different types of response (pointing to pictures, naming pictures, completing grammatically complex sentences). Elucidation of whether effects are general to oral language, or specific to assessment method, is required to inform accurate models of the processes that influence word reading development. Thus, we considered additional potential moderators of the relationship between preschool oral language and early school-age reading in our analyses to determine the specificity of any associations.

One moderator that we considered was whether the measure of oral language was receptive or expressive. In general, weak expressive vocabulary in toddlers is predictive of later reading comprehension deficits, although substantial variance remains unexplained (Bleses et al., 2016; Duff et al., 2015). The presence of both receptive and expressive vocabulary delay in preschool is associated with a greater risk of poor reading comprehension (Lyytinen et al.,

2005; Psyridou et al., 2018). However, there is also evidence that expressive vocabulary is a stronger predictor than receptive vocabulary of later reading comprehension in typical development (Roth et al., 2002). Given the range of assessment formats noted above, this meta-analysis makes a unique contribution by considering separately the influence of receptive and expressive measures, thus providing a method to determine whether previous findings of a relationship are general to vocabulary, or study specific.

Receptive and expressive measures of vocabulary have been observed to relate to different aspects of word reading skills in readers, even after several years of reading instruction. For example, one study examining the prediction of reading ability in 9- to 10-year-olds found that receptive vocabulary was more strongly associated with pseudoword reading and that expressive vocabulary more strongly associated with irregular word reading (Ouellette, 2006). These findings can be situated within the triangle model, in which comprehension of a word involves generating the semantic representation from its phonology, whereas production of a word requires generating the phonology from its semantics. If so, different tasks will load on the precision of spoken or meaning forms of words in different ways.

The specific pathways from vocabulary to word reading proposed by both the lexical restructuring hypothesis and the triangle model are each evident in research with preschoolers: receptive vocabulary is the predominant driver of pre-reading skills such as phonological awareness (Chiappe et al., 2004), and expressive vocabulary is more strongly associated with real word reading (Roth et al., 2002; Wise et al., 2007).

1.4. The potential influence of task complexity on the strength of the association between preschool oral language and early reading

Receptive and expressive measures of oral language can also differ substantially in the types of stimuli and responses that they require. Considering vocabulary, receptive measures typically involve selecting the picture that matches a spoken label, whilst expressive tasks can include both picture naming (in response to an experimenter-produced prompt) and production of definitions, which draw more heavily on semantics and word retrieval processes. For grammar, measures can involve a nonverbal response (e.g., selecting the picture that matches a spoken sentence), response to a verbatim stimulus (e.g., sentence repetition) or responses that involve coordination of several language and cognitive systems (e.g., sentence complexity calculated from narrative retells).

Factor analysis indicates that the dimensionality of oral language may be better explained by a model that distinguishes between the processing requirements of tasks, rather than the modality (receptive vs expressive) or the specific construct (semantics vs syntax) (Hoffman, et al., 2011). Previous meta-analyses of the relation between oral language and reading have treated these different aspects of oral language (vocabulary, grammar) and different types of measures (receptive, expressive) as indicators of the same latent construct (Hjetland et al., 2020), which prevents the behaviour being linked to computational and theoretical models of reading, such as the triangle model of word reading (Monaghan, 2023), as explained earlier. A meta-analytic framework that separates different tasks and types of measures enables us to test more specifically the adequacy and necessity of the different pathways proposed in models of reading ability and its development. This review of the literature motivated our plan to examine not only the separate influences of receptive and

expressive oral language measures, but also the influence of the complexity of response, on reading comprehension, word reading, and pseudoword reading.

1.5. The potential influence of assessment timings and school starting age on the strength of the association between preschool oral language and early reading

The age when preschool oral language and later school-age reading assessments are administered varies across studies. This potentially has significant practical and theoretical implications. Practically, it is important to know when the ideal time-point is to administer oral language measures to inform children's reading instruction needs. Theoretically, the strength of the association between preschool oral language and later reading may vary as children mature. Although preschool language is a strong predictor of early reading performance (LARRC & Chiu, 2018), the influence of oral language skills on reading comprehension increases during the first few years of schooling (Language and Reading Research Consortium (LARRC), 2015b). Thus, the influence of preschool vocabulary and grammar on later reading may depend on the interval between the predictor and outcome assessment points, which may affect its utility in informing targeted reading instruction.

This issue was explored, in part, in the moderator analyses conducted by Hjetland et al. (2020) by examining the influence of the age when the oral language assessments were administered, and also the age when reading was assessed. The authors did not find reliable moderator effects. However, their study did not address directly the interval between the two assessment points, and did not consider the different aspects of oral language and reading separately. Further, we note that Hjetland et al. (2020) included studies where children were in school settings, and therefore had exposure to reading instruction, at the time the oral

language assessment was taken. Thus, their analyses do not directly address the influence of oral language separate from reading instruction. To do so, we looked at the association between oral language assessments administered before school entry and later reading assessment, and also examined the potential moderating influence of the interval between the two time points.

The start of formal schooling can vary across the world from between 4 to 7 years of age. Thus, participants in different studies will vary in cognitive maturity (proxied by chronological age) and also the years of exposure to oral language before the onset of reading instruction. This issue was partially addressed in the meta-analysis conducted by Hjetland et al. (2020). They examined the strength of the association for studies that focused on early vs later stages of reading acquisition. They did not find substantially different strength of prediction. To build on this work, we examined school start age as a potential moderator.

1.6. The current study

This systematic review identifies critical questions about the relations between preschool oral language and beginning reading ability that have not been addressed in previous longitudinal studies or meta-analytic reviews. A meta-analysis including the many studies that have investigated the relationship between preschool oral language (vocabulary and grammar) and early reading ability (reading comprehension, word reading, and pseudoword reading) enables us to address the following specific aims in a robust way that minimizes the influence of variation amongst studies and potential measurement error:

(1) To estimate the overall effect size of the association between preschool oral vocabulary and grammar on early reading. Our study investigates the association between preschool oral language assessed prior to formal literacy instruction and early reading.

(2) To estimate the specific effect sizes for vocabulary and grammar separately. Our results shed light on distinct vs common relations between different oral language skills on early reading.

(3) To determine whether the effect size differs for reading comprehension, word reading and pseudoword reading. Our results provide insights into the oral language skills that are associated with different aspects of early reading.

(4) To establish whether the nature of the preschool oral language assessment (receptive vs expressive) influences the strength of the predictive relationship between preschool oral language and reading comprehension, word reading, and pseudoword reading. By comparing the influence of receptive and expressive measures, we are able to test different theoretical accounts of the role of oral language in early reading.

(5) To determine whether the complexity of the response required in early oral language assessments (simple – pointing or naming vs more complex definitions or usage in context) influences the strength of the predictive relationship between preschool oral language and early reading. Through this, we can determine whether this influences associations between preschool oral language and different aspects of early reading.

(6) To determine whether the interval between the administration of preschool and school age measures, and also the age at which formal reading instruction started, impacts the relationship between preschool oral language and reading. Through this, our study findings

speak to the transition to school and the earliest stages of reading, yielding insights for practice.

2. Method

This study was designed and preregistered according to the PRISMA guidelines (Page et al., 2021). The preregistration can be found on the PROSPERO platform at https://www.crd.york.ac.uk/RecordID=215162

2.1. Search strategy

Relevant studies were identified through searches within the databases: PsycInfo, ERIC, LLBA and ProQuest Dissertation Theses Global. We used a combination of free text terms and indexed tagged terms to identify records that were tagged with or included “vocab*” AND (“reading” OR “literacy” OR “comprehension”) in the title or abstract. This systematic search was conducted in December 2020. Following Hjetland et al. (2020), which included grammar, as well as vocabulary, we reran the search including also “grammar” in November 2022. This final search strategy was repeated in November 2023, the results of which we report here. The final search yielded a total of 15,855 records, with 14,644 unique records after removing duplicates. The records were exported from EndNote as .ris files and imported into Rayyan (https://www.rayyan.ai) for title and abstract screening. Our full search strategy can be found in the preregistration document: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=215162.

2.2. Eligibility criteria

Our focus was on the effect of preschool oral language (vocabulary and grammar) on early reading outcomes. Of the 89 samples included, 41 were non-English speaking populations and two were bilingual populations. Our main inclusion criteria were as follows:

(1) Studies had to be longitudinal, spanning preschool at time 1 to early school at time 2 with a measure of vocabulary or grammar at preschool age and a measure of reading (either word or pseudoword reading, and/or reading comprehension) at school age.

(2) Studies had to include typically developing children and/or populations with primary language or literacy disorders. Studies including only children with language impairments secondary to another developmental disorder (e.g., Autism Spectrum Disorder) were excluded.

(3) At time 2 (early school), participants' mean age needed to be 7 years 11 months or lower. Where the mean age was unavailable, we estimated it based on the school year children were in when the time 2 measures were taken.

See Table 1 for full details on all inclusion and exclusion criteria.

Table 1

Details of inclusion and exclusion criteria used to screen records

Include studies that:	Exclude studies that:
Include ***both*** a measure of preschool **vocabulary or grammar** and school age **reading** (longitudinal);	Report only concurrent measures of vocabulary or grammar and /or reading;

Measure language ability in children without known physiological or neurophysiological impairments (include even if this is a control group in an atypical development study);	Include ***only*** samples with a secondary language impairment (e.g., cochlear implant/ ASD/ cerebral palsy/ Down syndrome);
Measure children's language (vocabulary or grammar) and reading (real words, pseudowords, reading comprehension) from preschool up to 7 years, 11 months;	Report language and reading only at 8 years or older;
Report original empirical group data;	Report only a case study, review, or meta-analysis;
Are published in English.	Are not published in English.

2.3. Screening records

2.3.1. Title and abstract screening

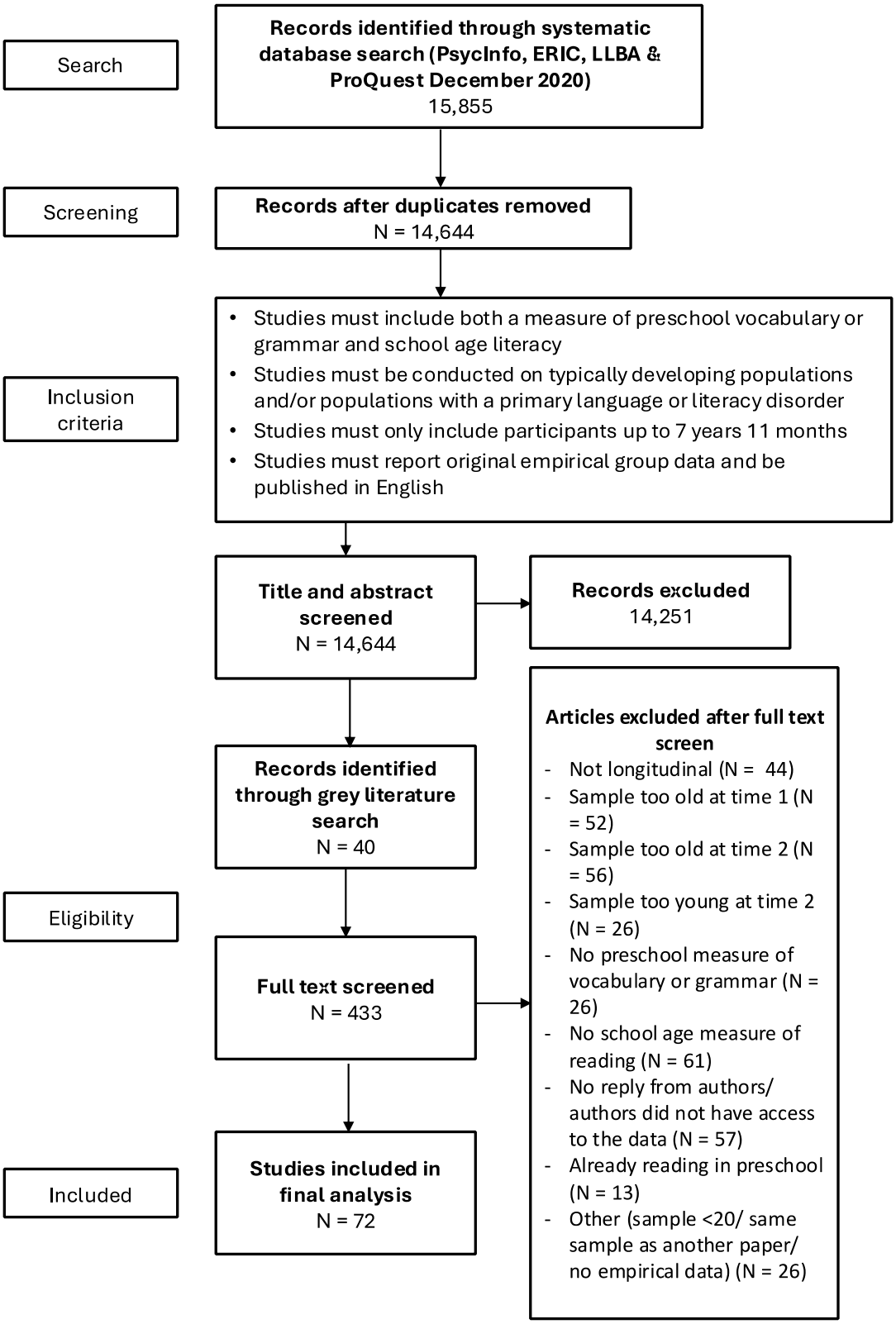
Five researchers, including the first author and four trained undergraduate psychology student researchers, screened the title and abstracts of the 14,644 unique records. We used an inclusive strategy to identify records that may have examined preschool vocabulary and grammar and reading (reading comprehension, word reading, and/or pseudoword reading) outcomes as a secondary aim. Any record indicating that a study was longitudinal from preschool to school age with a focus on language and reading was included at this step. The year of instruction called "kindergarten" is a preschool setting in some countries and a primary

school setting in other countries. Therefore, where an abstract mentioned kindergarten or kindergarteners without mentioning the country, the full text was screened and only those studies with a preschool sample were retained.

Reliability for each researcher was checked for 10% of the records. The accuracy for including and excluding records was 99%. The inter-rater reliability indicated high agreement (Kappa = 0.75; McHugh, 2012). There were 14 records with conflicts. These were resolved by the first author who checked the abstract and title for eligibility. Screening the abstracts and titles resulted in the exclusion of 14,251, leaving a total of 433 full texts to be screened, including 40 texts identified through grey literature searches (see Figure 1).

Figure 1

Flow chart of the included and excluded studies


Search
Records identified through systematic database search (PsycInfo, ERIC, LLBA & ProQuest December 2020)
15,855
Screening
Records after duplicates removed
N = 14,644
Inclusion criteria
• Studies must include both a measure of preschool vocabulary or grammar and school age literacy
• Studies must be conducted on typically developing populations and/or populations with a primary language or literacy disorder
• Studies must only include participants up to 7 years 11 months
• Studies must report original empirical group data and be published in English
Title and abstract screened
N = 14,644
Records excluded
14,251
Records identified through grey literature search
N = 40
Eligibility
Full text screened
N = 433
Articles excluded after full text screen
- Not longitudinal (N = 44)
- Sample too old at time 1 (N = 52)
- Sample too old at time 2 (N = 56)
- Sample too young at time 2 (N = 26)
- No preschool measure of vocabulary or grammar (N = 26)
- No school age measure of reading (N = 61)
- No reply from authors/ authors did not have access to the data (N = 57)
- Already reading in preschool (N = 13)
- Other (sample <20/ same sample as another paper/ no empirical data) (N = 26)
Included
Studies included in final analysis
N = 72

2.3.2. Full text screening

The first author and two trained undergraduate psychology researchers conducted full text screening of 433 records. An additional 304 studies did not meet our inclusion criteria and were excluded (see Figure 1). A further 57 studies were not included in the final sample because we were unable to obtain an *r* value (or data enabling us to calculate this) from the authors. Therefore, a total of 361 studies were excluded after full text screening.

After full text screening, 72 records with 23,387 participants were included for final data analysis. The section on missing data below provides details for estimating missing data for the moderator analyses. To establish reliability, two researchers each checked 5% of the records that they had not screened earlier; a total of 10% of the total records. The rate of agreement was excellent: 94.9%, (Kappa=0.90).

2.4. Data extraction and coding

Only studies that contained at least one of the predictor variables assessed in preschool and one of the outcome variables assessed in school were included in the final dataset. Here we detail this step of data extraction.

2.4.1. Predictor variables

Predictor variables included measures of preschool oral vocabulary and grammar. A vocabulary measure was included if it was either a receptive (e.g., point to or number a picture following a spoken word) or expressive (e.g., name a picture/ define a word) measure. A grammar measure was included if it was either a receptive or expressive measure, where children were assessed on their knowledge of sentence structure, syntax, morphosyntax or morphophonology.

2.4.2. Outcome variables

Outcome variables were included if they measured reading comprehension, word reading, and/or pseudoword reading. A measure of reading comprehension was included if a child read a passage and answered questions about the passage. A measure of word reading was included if the measure recorded accuracy or time to read aloud sentences, passages or words in isolation (e.g., a word or pseudoword list). If a study included measures of word reading and pseudoword reading, they were both included in the analyses.

2.4.3. Moderator variables and missing data

In order to examine how the type and timing of tests affected the association between oral language and later reading ability, we coded for a number of moderator variables. All studies that included a measure of vocabulary and grammar at preschool, as well as reading comprehension and/or word/pseudoword reading at school age, were included, regardless of the method used to assess these skills. For this reason, these variables were further distinguished to identify critical details to include in the analyses of potential moderators. The moderator variables were: modality of oral language measure (receptive vs expressive); complexity of response in oral language task (simple vs complex); interval between preschool oral language assessment and school-age reading assessment; and age of onset of schooling (to indicate the start of formal reading instruction). Some studies did not report the details required for the moderator analyses. Where more information was required, the first authors were contacted. Where this information was not provided, the variables were retained for the main analyses but excluded from the moderator analysis.

Modality of oral language assessment: Receptive and expressive measures of vocabulary and grammar

Preschool oral language measures of vocabulary and grammar were coded as receptive or expressive assessments. Where this information was missing from a paper, we found the details about published assessments online. When a paper combined the receptive and expressive vocabulary or grammar measures to provide one score, we contacted the authors to request separate data. If there was no response or data provided, this correlation was excluded from the moderator analysis examining the effect of expressive and receptive vocabulary or grammar measures (N=14).

Complexity of response type

Preschool oral language measures of vocabulary and grammar were coded as requiring a simple (picture pointing, naming, sentence repetition) or more complex (word definitions, sentence correction, estimates taken from story recall tasks) response. There were 226 simple and 63 complex vocabulary data points, and 111 simple and 80 complex grammar data points. Where there was insufficient detail in the paper to allow us to establish whether a measure required a simple or complex response, we searched for this information online. If we were unable to find the details, these data points were excluded from the moderator analyses examining the effect of complex and simple measures. In addition, measures that used parental questionnaire were excluded from these analyses (vocabulary N=4) or where the complexity could not be determined (vocabulary N=15).

Interval between time 1 (preschool oral language assessment) and time 2 (school-age reading assessment)

Mean chronological age was coded in months. The mean age of the participants in the studies included was 57.12 (19-82) months at time 1 and 77.15 (56-93) months at time 2. The interval between time 1 and time 2 was calculated by subtracting the mean age at time 1 from the mean age at time 2. If the mean age of participants was missing either at preschool or in school, the authors were contacted. If the authors could not provide this information, the age was estimated based on the preschool or school year. If we could not estimate this, the paper was excluded from the analyses examining the effect of the interval between preschool and school age assessments (age at time 2, N=26).

Onset of formal reading instruction

The age of formal reading instruction onset was estimated based on the minimum age children can start school in the reported country. For Canada and the USA, where the age children begin school differs by state/province, we used the state/province specific-minimum school start age. Where we were unable to identify which county the participants were based, we contacted the authors. If the authors did not reply with this information, it was estimated from other details provided in the paper. If this was not possible to estimate, this study was not included in the analysis examining the impact of the onset of formal reading instruction (N=1).

2.5. Risk of bias and study quality

2.5.1. Risk of publication bias

Publication bias occurs when studies with significant results or larger effect sizes are favoured for publication over studies with non-significant results or smaller effect sizes

(Quintana, 2015). To check for publication bias, we ran rank correlation tests (Begg & Mazumdar, 1994) to establish an objective measure of publication bias and created funnel plots to visualise the individual effect sizes of each study.

2.5.2. Study quality risk measure

We calculated study quality risk using the eight criteria outlined in Hjetland et al. (2020). See Table 2 for a list of these criteria and the coding used to determine risk level. A higher score indicates greater methodological risk.

Table 2

Criteria and coding used to determine study quality.

Criteria	Low risk (0)	Higher risk (1)	High risk (2)
Sampling procedure	Random	Convenience	NA
Attrition	Reported	Not reported	
Instrument type	Combination of standardised and research made	Only standardised	Only researcher made
Test reliability	Reported for all measures	Reported for some measures	Reported for no measures/ unclear
Floor or ceiling effects	No floor/ ceiling effects	Floor/ ceiling effects for one of more measures/ not reported	NA

Criteria	Low risk (0)	Higher risk (1)	High risk (2)
Missing data	Method better than listwise	List-wise deletion/ no report of how missing data was handled	
Latent variables	Latent variables used	Latent variables not used	
Statistical power/ sample size	> 150 participants	70-150 participants	< 70 participants

2.6. Correcting for non-independent data

This meta-analysis had two main predictor variables (oral vocabulary and grammar) and three outcome variables (reading comprehension, word reading, and/or pseudoword reading). Since many of the studies included reported more than one correlation from the same sample of children, the data were dependent. Different methods exist to handle dependencies within data and there is no universally agreed gold-standard. One method is to aggregate effect sizes from the same sample into one composite effect size (Fisher & Tipton, 2015). However, since we were interested in the effects of different skills it was not possible to aggregate the effect sizes for this meta-analysis. Another method recommended for handling dependent data is to use robust variance estimation (Fisher & Tipton, 2015; Hedges et al., 2010; Tanner-Smith et al., 2016). This method can be used to summarize differences between groups even when the

relationship between effect sizes is unknown. Thus, we use robust variance estimation to control for non-independent effect sizes in our analyses.

2.7. Meta-analytic procedures

The data analyses were conducted in R using R Studio (R Core Team, 2020). First, we transformed each correlation coefficient from *r* to Fisher's Z scores to calculate the corresponding sample variances. We implemented robust variance estimation using the RobuMeta package in R (Fisher & Tipton, 2015) with a correlated effects working model. For the moderator analyses, where the number of studies included was below 40, we used the adjustments available for small samples in the RobuMeta package. We ran sensitivity analyses to check if the results were robust across different levels of correlations. The effect of the moderating factors was also tested using regression models in the RobuMeta packages.

3. Results

A total of 72 studies, with 89 unique samples, comprising 23,387 participants and 499 correlations were included. We report the number of effect sizes (*k*), the number of clusters (*m*), and the degrees of freedom (*df*) for each RVE. See Table 3 for a summary of the number of correlations available across time 1 and time 2 measures.

Table 3

The number of correlations between time 1 and time 2 variables

Skill	Time 2 Reading comprehension	Time 2 Word reading	Time 2 Pseudoword reading
Time 1 Vocabulary	67	191	50
Time 1 Grammar	51	109	31

3.1. Main analysis: The overall association between preschool oral vocabulary and grammar and school-age reading comprehension, word reading, and pseudoword reading

3.1.1. Vocabulary

There was a significant association between preschool oral vocabulary and reading comprehension: r = .300, 95% CI [0.262, 0.359], k = 67, m = 31, df = 26.4, p < .001. The true heterogeneity between studies was substantial, I^2 = 71.43%, τ^2 = .010. A sensitivity analysis, with a correlation level of outcomes set to a range of 0-1, produced stable results. τ^2 was constant across the range (.010) indicating no differences in effect size or standard error (SE). There was also a significant association between preschool vocabulary and word reading: r = .278, 95% CI [0.254, 0.316], k = 190, m = 64, df = 57, p < .001. The true heterogeneity between studies was substantial, I^2 = 78.13%, τ^2 = .012. A sensitivity analysis, with a correlation level of outcomes set to a range of 0-1, produced stable results. τ^2 was constant across the range (.012-.013) indicating no differences in effect size or SE. Likewise, there was also a significant association between preschool vocabulary and pseudoword reading, r = .259, 95% CI [0.219, 0.310], k = 50, m = 21, df = 17.2, p < .001. The true heterogeneity between the studies was moderate, I^2 = 45.66%, τ^2 = .006. A sensitivity analysis, with a correlation level of outcomes set to a range of 0-1, produced stable results; τ^2 was constant across the range (.006) indicating no differences in effect size or SE.

In summary, there was a significant positive predictive relationship between preschool oral vocabulary and school age reading comprehension, word reading, and pseudoword

reading. The strength of the association was similar for all three outcome variables, and there was considerable overlap in the confidence intervals for each.

3.1.2. Grammar

There was a significant association between preschool oral grammar and reading comprehension: r = .260, 95% CI [0.176, 0.357], k = 51, m = 17, df = 14.7, p < .001. The true heterogeneity between the studies was large, I^2 = 73.87 %, τ^2 = .017, and sensitivity analysis, with a correlation level of outcomes set to a range of 0-1, produced stable results; τ^2 was constant across the range (.017) indicating no differences in effect size or SE. Similarly, there was also a significant association between preschool grammar on word reading: r = .316, 95% CI [0.272, 0.382], k = 109, m = 25, df = 22.4, p < .001. The true heterogeneity between studies was also large, I^2 = 77.48%, τ^2 = .020. A sensitivity analysis, with a correlation level of outcomes set to a range of 0-1, produced stable results; τ^2 was constant across the range (.020) indicating no differences in effect size or SE. Finally, there was also a significant association between preschool grammar and pseudoword reading: r = .265, 95% CI [0.117, 0.368], k = 31, m = 11, df = 9.10, p < .001. As for the other outcome measures, the true heterogeneity between the studies was large, I^2 = 66.72%, τ^2 = .015, and sensitivity analysis, with a correlation level of outcomes set to a range of 0-1, produced stable results; τ^2 was constant across the range (.015) indicating no differences in effect size or SE.

In summary, there was a significant positive association between preschool oral grammar and school age reading comprehension, word reading, and pseudoword reading. The strength of the association was similar for all three outcome variables, and there was considerable overlap in the confidence intervals for each.

3.2. Moderator analyses

The significance of true heterogeneity of variance between the studies justified investigating whether or not the four moderators influenced the size of these effects. In the first set of moderator analyses, we examined whether receptive versus expressive measures of preschool vocabulary and grammar impacted the size of the association between preschool oral language skills and school age reading comprehension, word reading, and/or pseudoword reading outcomes. The contrasts for receptive and expressive measures were set as: receptive = -1, expressive = 1. The second set of moderator analyses examined the influence of complexity of response required for the oral language assessment. The contrasts for simple and complex oral language assessments were set as: simple = -1, complex = 1. The third set of moderator analyses examined whether or not the length of time between the assessment of preschool measures and subsequent reading comprehension, word reading, and/or pseudoword reading outcomes influenced the strength of the association. The fourth set of moderator analyses examined whether or not there was an effect of age of formal reading instruction onset on the strength of the association.

The results of these analyses are summarised in Tables 4 and 5. For each analysis, the sensitivity was stable, indicating no differences in effect size or SE. The results indicate that, with one exception, there was no influence of any moderators on the association between preschool oral vocabulary and grammar and school age reading. The only exception was the influence of the age of onset for formal reading instruction on the relationship between vocabulary and word reading: There was a larger association between preschool vocabulary and school-age word reading for earlier school-starting age.

Table 4

Results of the moderator analyses examining the influence of each moderator on the association between preschool vocabulary and school-age reading

Moderator variable	Number of effect sizes (*k*)	Number of studies *(m)*	Effect size *(r)*	*df*
Modality of oral vocabulary measure: Receptive vs expressive				
Reading comprehension	65	31	.002, 95% CI [-0.042, 0.045]	25.20
Word reading	182	64	-.005, 95% CI [- 0.035, 0. 025]	55.90
Pseudoword reading	49	21	-.014, 95% CI [-0. 063, 0.034]	11.40
Complexity of response				
Reading comprehension	61	29	.008, 95% CI [-0.019, 0.074]	6.56
Word reading	183	63	.016, 95% CI [-0.037, 0.062]	19.2
Pseudoword reading	45	19	-.008, 95% CI [-0.093, 0.077]	6.59
Interval between assessment of oral language and reading				
Reading comprehension	65	29	.004,	12.00

			95% CI [-0.001, 0.010]	
Word reading	166	56	.002,	14.70
			95% CI [-0.002, 0.007]	
Pseudoword reading	50	21	.003,	7.24
			95% CI [-0.003, 0.008]	
Onset of formal reading instruction				
Reading comprehension	67	31	.002,	12.4
			95% CI [-0.002, 0.005]	
Word reading	189	63	-.004**,	20.8
			95% CI [-0.007, -0.0007]	
Pseudoword reading	50	21	-.003,	4.91
			95% CI [-0.008, 0.002]	

** p=<.05

Table 5

Results of the moderator analyses examining the influence of each moderator on the association between preschool grammar and school-age reading

Moderator variable	Number of effect sizes (*k)*	Number of studies *(m)*	Effect size *(r)*	*df*
Modality of oral grammar measure: Receptive vs expressive				
Reading comprehension	50	16	-.014, 95% CI [-0.101, 0.073]	13.60
Word reading	108	24	.014, 95% CI [-0.040, 0.067]	21.40
Pseudoword reading	30	10	-.005, 95% CI [-0.138, 0.048]	5.70
Complexity of response				
Reading comprehension	56	17	.057, 95% CI [-0.019, 0.134]	10.20
Word reading	109	25	.050, 95% CI [-0.014, 0.114]	8.93
Pseudoword reading	26	10	-.064, 95% CI [-0.162, 0.034]	6.24
Interval between assessment of oral language and reading				
Reading comprehension	51	17	-.0007, 95% CI [-0.009, 0.007]	7.52

Word reading	109	25	-.003, 95% CI [-0.007, 0.002]	7.11
Pseudoword reading	31	11	-.002, 95% CI [-0. 007,0.003]	5.26
Onset of formal reading instruction				
Reading comprehension	51	17	.001, 95% CI [-0.007, 0.008]	5.35
Word reading	109	25	.004, 95% CI [-0.002, 0.009]	8.97
Pseudoword reading	31	11	-.005, 95% CI [-0.017, 0.007]	4.90

3.3. Study quality

Table 6 and Figure 2 summarise the risk of methodological bias in the studies. Where a study had more than one group, we calculated the risk for each group. There was low risk of bias across almost half of the studies for missing data, test reliability, and attrition. For most studies there was moderate to high risk of bias across the remaining factors. Of note, many of the studies lacked the necessary information for us to ascertain the risk of bias for each of these factors; further detail on this can be found in Table 6.

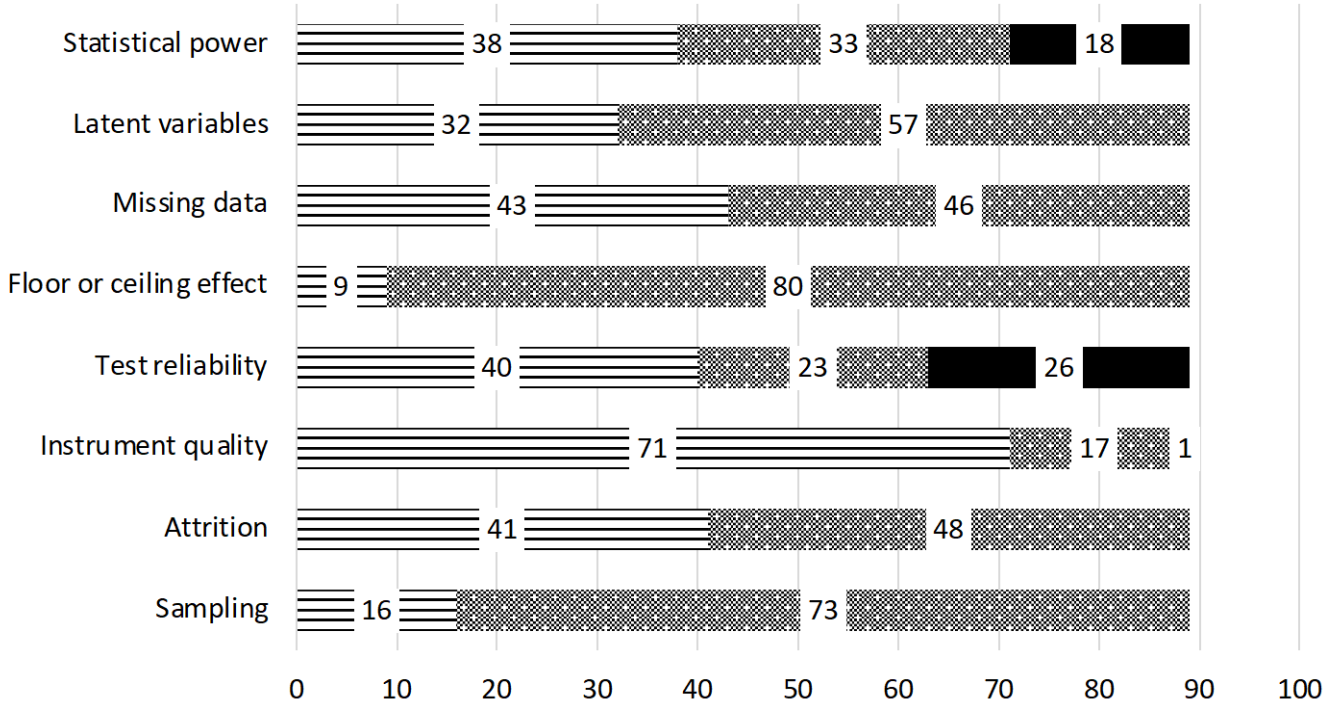
Table 6

Risk of methodological bias across all included studies.

Criteria	Result
Sampling	Random sampling was used for only 16 of the 89 groups of participants included in our analyses. For six groups it was unclear or not reported if convenience or random sampling was used.
Attrition	Rate of attrition was unclear or not reported for 20 groups.
Instrument Quality	17 groups were assessed using only standardised assessments. Most studies used a mixture of standardised and research-made instruments (*n*=71).
Test reliability	For 14 groups, the test reliability of the measures was not reported or was taken from the test manual. For 12 groups, the reliability was unclear.
Floor or ceiling effects	Only 9 groups had no floor or ceiling effects.
Missing data	For 44 of groups, how missing data was handled was either unclear or not reported.
Latent variables	Latent variables were not used for 57 groups.
Statistical power	There were 18 groups with fewer than 70 participants, 33 groups with 70-150 participants and 38 groups with more than 150 participants.

Figure 2

Study quality of the studies included in the main analysis.



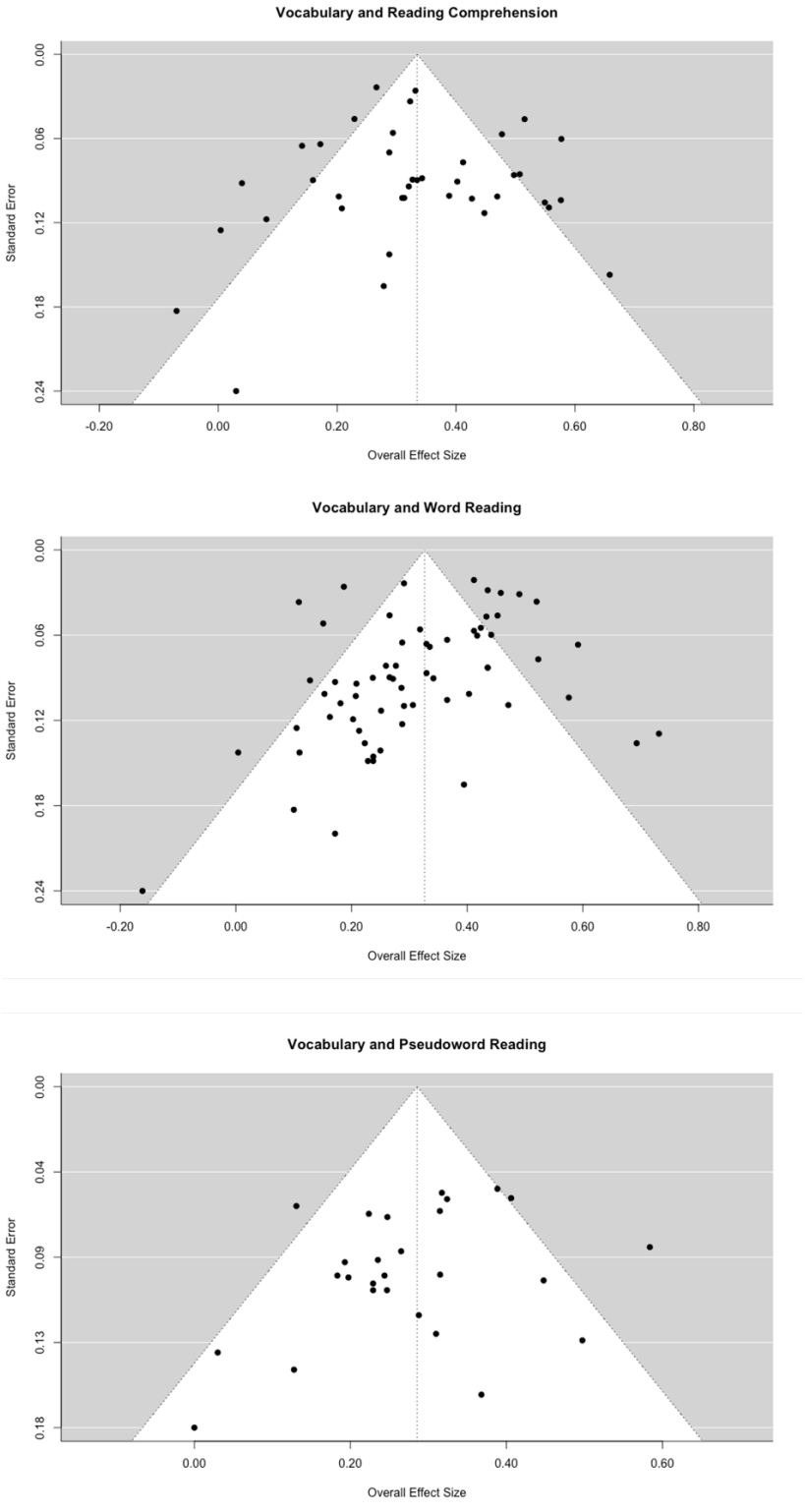
	Sampling	Attrition	Instrument quality	Test reliability	Floor or ceiling effect	Missing data	Latent variables	Statistical power
0 (low risk)	16	41	71	40	9	43	32	38
1 (moderate risk)	73	48	17	23	80	46	57	33
2 (high risk)			1	26				18

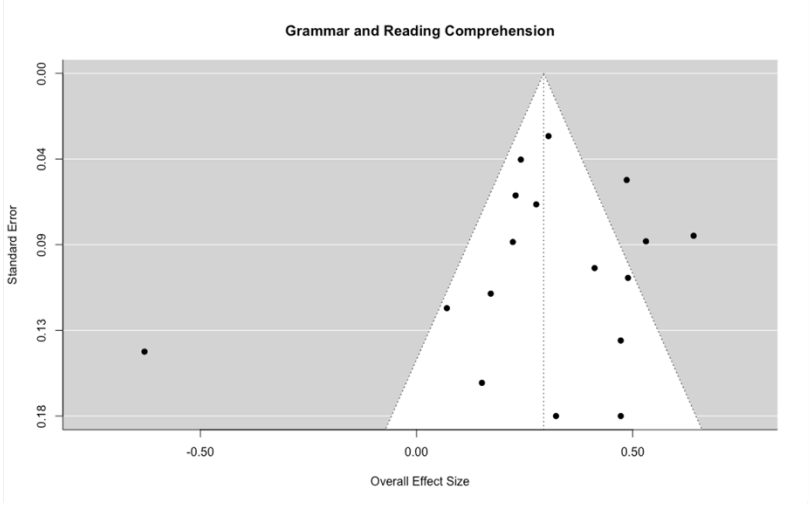
3.4. Publication bias

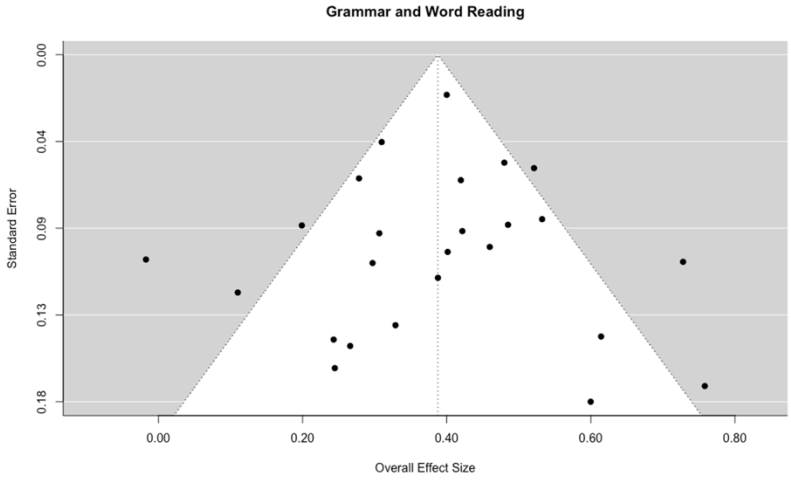
We used funnel plots and Egger's test (Egger, Davey Smith, Schneider, & Minder, 1997) to examine the potential presence of publication bias for each of the six associations examined in our main analyses (shown in Figure 3). Data aggregation was performed using the MAc package in R providing one correlation for each study within each association. Egger's test assesses the symmetry of a funnel plot in the context of a meta-analysis. The Egger's tests showed that there was significant asymmetry in the funnel plots for one association: vocabulary and word reading. The results of Egger's test for each association were: vocabulary and reading comprehension (ß = 0.384, Z = -0.848, *p* = .397); vocabulary and word reading (ß = 0.423, Z = -2.714, *p* = .006); vocabulary and pseudoword reading (ß = 0.378, Z = -1.380, *p* = .168); grammar and reading comprehension (ß = 0. 428, Z = -0.909, *p* = .363); grammar and word reading (ß = 0.378, Z = 0.127, *p* = .899); and grammar and pseudoword reading (ß = 0.362, Z = -0.308, *p* = .758).

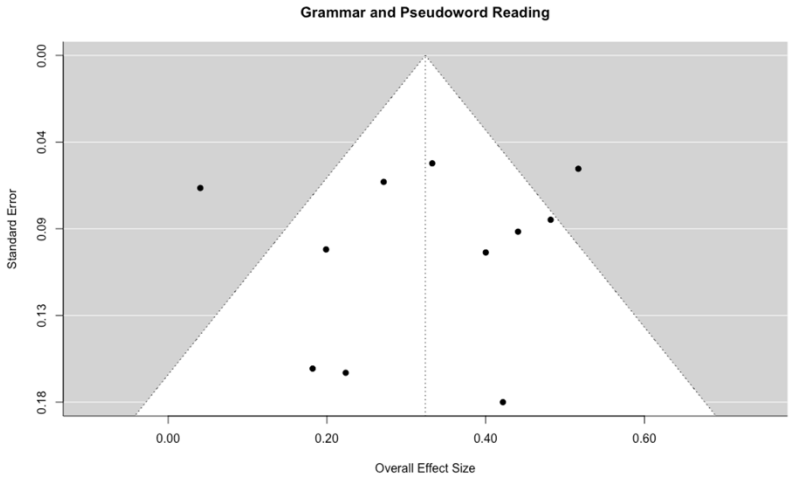
Figure 3

Funnel plots of all studies included in main analysis









4. Discussion

This meta-analysis confirmed a significant and moderate association between early oral language (vocabulary and grammar) and later reading comprehension, which has been reported previously (Hjetland et al., 2020). We extend previous reviews and advance knowledge on this association in several important ways. First, we examined the influence of preschool oral language exclusively; previous research has not focused on this association for oral language skills assessed prior to the start of formal literacy instruction. Second we examined the separate influence of vocabulary and grammar on early reading; previous meta-analytic reviews have focused on a latent construct (or composite) measure of oral language. Third, we examined the association between oral language and three different aspects of early reading: reading comprehension, word reading and pseudoword reading; previous meta-analytic reviews have not discriminated between them. Finally, we examined the potential moderating influence of critical task factors (receptive vs expressive measures of oral language, simple vs. complex response) and the influence of the interval between the preschool oral language and later reading assessments, and school starting age. The theoretical and practical implications are discussed below.

4.1. The role of preschool vocabulary and grammar on early reading comprehension, word reading, and pseudoword reading

Our main analyses demonstrated that preschool assessments of vocabulary and grammar were each significantly associated with later reading comprehension, word reading, and pseudoword reading. The critical role of a composite measure of early oral language in early reading comprehension is well established in individual studies and a previous meta-analysis (Hjetland et al., 2020). For the reasons outlined in the Introduction, such studies

cannot examine potentially unique influences of vocabulary and grammar. Our study advances knowledge by demonstrating that, when considered separately, preschool vocabulary and grammar make comparable contributions to the determination of early reading comprehension.

Vocabulary and grammar are regarded as foundational skills for reading comprehension: Words are the building blocks of sentences, and sentences are the building blocks of prose-level comprehension. In theories of language development, there are proposals that vocabulary and grammar are separable, being underpinned by different learning mechanisms (Pinker, 1998), but also that they are interdependent, with growth driven by the same learning mechanisms (Brinchmann et al., 2019; Hoff et al., 2018; Marchman et al., 2004; Plunkett & Marchman, 1993). Furthermore, it has been argued that early grammatical development depends on a critical lexical base (Dixon & Marchman, 2007; Marchman & Bates, 1994). Given the latter view, it is perhaps not surprising that these mutually supportive skills cannot be reliably separated statistically in preschool children (Language and Reading Research Consortium (LARRC), 2015a; Tomblin & Zhang, 2006). This is one potential explanation for the similar strength of association found here. Indeed, it may not be practical (or useful) to distinguish the unique contribution of oral vocabulary and grammar to the prediction of early reading at this stage in development.

We were not able to examine the impact of preschool oral language on reading comprehension while controlling for word reading skills, because too few studies included measures of both variables: Of the 72 studies included, 41 measured only reading comprehension and not word reading, and 9 measured only word reading and not reading

comprehension. We thus chose to optimise statistical power to determine meaningful relationships between preschool oral language skills and reading comprehension and word reading separately, rather than only focus on the 30 studies that included both. Further research is thus needed to establish the unique role of oral language on reading comprehension.

We established that, in general, the strength of the association between preschool vocabulary and grammar was comparable for both real word and pseudoword reading. Our analytic approach enabled us to determine the extent to which these oral language skills were related to children's ability to decode novel orthographic stimuli when reading words with both phonological and semantic content and, thus, speaks to theoretical models of the relation between oral language, specifically vocabulary, and different aspects of word reading.

The predictive association between preschool vocabulary and word reading aligns with theoretical models of word reading specifically (Chang et al., 2019; Harm & Seidenberg, 2004; Metsala & Walley, 1998) that have shown the importance of oral language skills on early reading development. However, we did not find support for the proposal that oral language facilitates the pronunciation of words that cannot be read accurately with phonological decoding skills alone (Harm & Seidenberg, 2004; Ouellette, 2006; Ricketts et al., 2007); there was no difference in the strength of the relationship between preschool vocabulary and early word reading for word and pseudoword stimuli.

Differences in these relations may be evident in older, more fluent readers, because they are proposed to emerge from interactions with print during the acquisition of word reading skill (Harm & Seidenberg, 2004). We note that studies that report a specific relation

between semantics and real word reading have studied older populations (Ouellette, 2006; Ricketts et al., 2007). In this meta-analysis, we were interested to examine the very earliest stages of word reading development. Thus, we might not expect a specific influence of preschool semantic skills on early word reading. Our data, and the triangle model, suggests the influence of semantic knowledge requires a period of exposure to print and, furthermore, the relations between word reading and vocabulary knowledge may share reciprocal relations over time (Verhoeven et al., 2011). However, we note that longitudinal studies across this period of development are needed to determine whether there is an emergence and strengthening of this relationship with age.

Preschool grammar shared significant and comparable associations with later word reading and pseudoword reading, which were of similar magnitudes to the assocations between vocabulary and these two indicators of word recognition. This finding indicates the value of both aspects of pre-school language (vocabulary and grammar) for word recognition skills. Grammar may support the reading of both words and pseudowords in at least two ways. First, morphological knowledge aids the reading of multimorphemic words and pseudowords that contain common morphemes such as *gaked* or *lagician* (Deacon & Kirby, 2004). Second, syntactic knowledge enables readers to use the syntactic constraints of a sentence to decode unfamiliar words and, through that, consolidation of orthographic knowledge, including grapheme-phoneme correspondences (Tunmer, 1989). We note, however, that the association between grammar and both word and pseudoword reading may be indirect due to shared variance with another variable such as phonological awareness or working memory (Deacon & Kirby, 2004; Gottardo et al., 1996). We recommend futures studies report separate correlations

between different measures of grammar and word recognition skills, where available, to enable future tests of the reproducibility of these findings and determination of the potential mechanisms for the relationship.

4.2. Examination of potential moderators

Our examination of task factors that might influence the relation between oral language (specifically vocabulary and grammar) and reading (reading comprehension, word reading, and pseudoword reading) allowed us to determine if effects were general to both aspects of oral language or specific to the task modality or method of assessment. As a result, our findings can inform more accurate models of the processes that influence early reading ability. Contrary to proposals in the literature, expressive language was not more strongly associated with reading comprehension and word reading than receptive language (Roth et al., 2002). The triangle model of reading predicted that expressive and receptive oral language skills are somewhat distinct, in that one requires mapping from semantics to phonology, and the other requires mapping from phonology to semantics. In computational models of these skills, the training tends to be separate (e.g., Harm & Seidenberg, 2004), but the results of the meta-analysis provide no evidence to support separation of these mappings according to their direction. Future computational implementations of reading could thus incorporate joint rather than separate training of expressive and receptive tasks (e.g., Monaghan, 2023). Furthermore, the complexity of the response required for the oral language assessment did not moderate the strength of the association, in contrast to Hoffman et al. (2011). This pattern was consistent across both vocabulary and grammar.

We distinguished complexity of response into simple (picture pointing, naming, sentence repetition) and complex (word definitions, sentence correction, estimates taken from story recall). One explanation for our findings comes from a consideration of some of the fundamental strengths of a meta-analysis. The studies in our dataset included a range of assessments for oral vocabulary and grammar, potentially introducing various features of testing which may have added noise and, consequently, impacted any differences between expressive and receptive assessments. For example, some expressive measures of vocabulary require the child to name a picture; others require the child to produce a definition. Arguably the latter task draws more heavily on semantic knowledge (and other language knowledge and cognitive processes). One findings indicate that neither the nature of the oral language assessment nor the aspects of oral language assessed (expressive and receptive) reliably influences the strength of the association between oral language and early reading comprehension and word reading (Psyridou et al., 2018). We note, however, that our meta-analytical approach to minimise between-study variability may be masking identification of the critical features of oral language tasks that are more strongly associated with early reading. There may also be other task-specific factors not examined in our moderator analyses that have an influence on task performance.

A unique feature of our work was to consider only measures of oral vocabulary and grammar taken before the onset of schooling and, therefore, formal reading instruction. Our findings align with models of reading and prior studies that posit a role for early meaning-related skills, such as vocabulary and grammar, and later reading comprehension (Kendeou et al., 2009; LARRC & Chiu, 2018). Our findings further indicate a role for preschool oral language

on early word reading. This is in contrast with some models of word reading specifically that have proposed that the relations between different aspects of word-level knowledge - orthography and both phonology and semantics are fostered through the interaction with print that occurs through learning to read (Castles & Coltheart, 2004; Harm & Seidenberg, 2004). However, such findings can be explained in relation to the lexical restructuring hypothesis and extensions of the triangle model that propose that the development of pre-literacy vocabulary results in increasing precision of phonological codes (Chang et al. 2019; (Harm & Seidenberg, 1999; Metsala & Walley, 1998).

As a potential moderator, we examined the interval between the assessments of preschool oral language and school-age reading. The time interval did not influence the strength of the association between oral language and any of the three aspects of early reading. Together, these findings accord with the strong theoretical and empirical basis for the oral language foundations of reading comprehension (Kendeou et al., 2009; LARRC & Chiu, 2018; Storch & Whitehurst, 2002) because the influence of oral language on reading is robust and not easily disrupted by variations in assessment timing. They further indicate a robust relation between preschool oral language and word reading.

Although, the onset of schooling (and, therefore, reading instruction) varies by country, this did not have a general influence on the association between preschool oral language and early reading. The notable exception was that there was a stronger relation between preschool oral vocabulary and word reading, for children who started school earlier. In general, later school start age is associated with countries that have more transparent orthographies, which facilitates the acquisition of decoding (or grapheme to phoneme mapping) skills (Florit & Cain,

2011). Our sample was weighted towards studies of learning to read in more opaque orthographies (50.9% of studies in this analysis sampled children in the US and UK) for which decoding skills alone are insufficient to accurately pronounce all words (Share, 2008). Thus, our findings may indicate that stronger oral language skills facilitate word acquisition for these writing systems. The nature of reading instruction will also vary across schooling system and cultures; future research to disentangle the influence of orthography and schooling system is needed.

Practically, as noted above these findings provide strong evidence that a child's level of preschool oral language can reliably predict their reading ability and, therefore, their development needs from the earliest stages of reading instruction. Given the strong association between vocabulary and grammar and both reading comprehension and word reading, these findings indicate that the assessment of either aspect of oral language could usefully inform a child's readiness for reading instruction and inform individual learning support. These results confirm the importance of supporting early oral language skills before reading instruction begins (Bleses et al., 2016; Castles & Coltheart, 2004; Chang et al., 2019; Dickinson et al., 2010; Duff et al., 2015; Hjetland et al., 2020; Muter et al., 2004; Ricketts et al., 2007).

4.3. Strengths, limitations, and future research

A strength of our approach, already noted, was the framework of a systematic review and meta-analysis which samples across a wide range of measures, cultures, and labs thus mitigating bias from these critical influences. In this study, there was no evidence of publication bias in four out of the six main analyses, but we found evidence of publication bias in two: vocabulary and word reading, and vocabulary and pseudoword reading. Our assessment of

study quality indicated a lack of information for a full and proper evaluation of the results in many studies, and so we recommend more detailed reporting, in future, of critical methodological details and correlations. For example, attrition rates, rates of floor or ceiling effects, and handling of missing data were lacking for many of the studies included. Inclusion of such information going forwards will enable new and more robust and comprehensive meta-analytic reviews as the evidence base grows.

There are several limitations to our systematic review and meta-analysis in addition to those already noted, and we discuss the three most pertinent. First, due to constraints from our pre-registered design and, critically, the number of available studies, we did not look at the influence of oral language on reading comprehension while controlling for the influence of word reading. Given the influence of oral language on both reading comprehension and word reading found here, and in other work (LARRC, 2015a), including this control would be useful to identify direct and unique impacts. Second, we were not able to examine different types of language assessment, for example standardised direct measures contrasted with parent checklists and/or spontaneous speech samples. Future work should include such these contrasts, which would usefully inform practice. Further, we did not contrast orthographies that differ in transparency (for alphabetic writing systems) or unit of coding (e.g., alphabetic vs morphosyllabic). Such comparisons are necessary to determine the generalisability of these findings and should be a consideration for future research (Melby-Lervag & Lervag, 2014). Finally, we did not include narrative in our examination of oral language. This was due to our focus on foundational (or lower-level) oral language skills, namely vocabulary and grammar.

Future work should extend this study by considering narrative skills as well, to determine its relative influence on different aspects of early reading.

4.4. Implications and conclusions

In sum, we confirmed a previous meta-analytic review showing a strong association between early oral language and early reading comprehension and word reading. Our work extended the previous literature by focusing exclusively on preschool measures of oral language taken before the start of formal literacy instruction, and by examining the strength of the association for vocabulary and grammar, and also word and pseudoword reading, separately. Our findings suggest that, in general, the effects are comparable across these constructs. We also examined previously unexplored moderators, specifically the modality of the preschool oral language assessments, the complexity of the response in the oral language task, the interval between assessment time points, and the onset of formal schooling. The onset of schooling moderated the strength of association between vocabulary and later word reading; no other moderators had a significant influence. Taken together, our findings indicate that a range of oral language measures taken in preschool can serve as a reliable predictor of early reading outcomes. They further add to the evidence base for the importance of early language for educational outcomes, supporting calls for preschool interventions to support later literacy success.

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