Oral vocabulary knowledge and learning to read new words: A theoretical review

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Abstract

In this theoretical review, evidence for the link between spoken and written word knowledge is summarised, highlighting the specific hypotheses posed in this field and the extent to which they are informative regarding causation. A brief overview of major theories of orthographic learning draws attention to how each characterises the role of oral vocabulary within the learning process, and the timing of its influence. The theoretical foundations and evidence for two cognitive mechanisms that seek to explain the relationship between spoken and written word knowledge are outlined, drawing attention to a key difference between them: the proposed timing of the effect. *Set for variability* (or *mispronunciation correction*) is thought to operate from the point of visual exposure, while *orthographic skeletons* are thought to exert an influence on written word learning that begins before exposure to written words. The review closes with a discussion of directions for future research.

Spoken language developmentally precedes the emergence of reading, from which point the two skills remain intimately intertwined throughout development. It is well known that aspects of children's oral language skills make strong contributions to their early progress in learning to read. Prominent among these is children's appreciation of the sound structure of their native spoken language, or phonological awareness (Rack et al., 1994; Wagner & Torgesen, 1987). Provided that children also have some knowledge about the mappings between letters and sounds, they gradually come to understand that letters code for speech sounds (Byrne, 1998; Ehri, 1992). Together these skills underpin children's emerging ability to build pronunciations of printed words via a process of translating from letters to sounds, or phonological decoding (Melby-Lervåg et al., 2012). While there is broad consensus regarding the central roles of phonological awareness and decoding skill within early literacy acquisition, other aspects of children's language ability are also thought to contribute to reading development (Castles & Nation, 2006; Nation & Castles, 2017; Nation & Snowling, 2004). Children's oral vocabulary knowledge is one such factor.

Oral vocabulary refers to knowledge about spoken words and is one component of broader oral language skill. Spoken word knowledge can be fractionated into two separable, yet tightly connected aspects of representation: one reflecting knowledge about the pronunciation of spoken words and another reflecting knowledge about meaning (Levelt et al., 1999). Spoken word knowledge has long been known to play a causal role in the development of children's reading comprehension skills, and on this basis, oral vocabulary is generally acknowledged as a key component of reading instruction programs (see Gough & Tunmer, 1986; National Reading Panel, 2000; Stanovich, 1986). Notwithstanding the important role oral vocabulary knowledge plays within reading comprehension processes, more recent evidence suggests that oral vocabulary also makes a causal contribution to the process of learning to read new written words. Specifically, if a reader knows the spoken

form of a word, they are more likely to be able to read it accurately and efficiently than similar words that are unfamiliar orally. This finding is important because it suggests that oral vocabulary plays a broader role in reading acquisition than has traditionally been recognised. If oral vocabulary and word reading are causally related, this implies that there may be potential to utilise this relationship within reading instruction programs to support children's word reading outcomes (in addition to reading comprehension outcomes). In order to design reading instruction programs that effectively exploit the relationship between oral vocabulary and learning to read new words, understanding precisely how this relationship operates is essential. That is, we must understand the nature of the cognitive mechanism or mechanisms that support the causal link between spoken and written word knowledge.

In this theoretical review, our aims are threefold. First, we aim to review evidence for the association between oral vocabulary and word reading. Using a narrative style, we will summarise data from a range of research designs, drawing attention to the specific hypothesis tested by each approach. We will distinguish hypotheses that imply causation from those that do not. Ultimately, we will build the case that oral vocabulary knowledge makes a causal contribution to the process of learning to read new words. Second, we will briefly describe important theories of orthographic learning, drawing attention to how each describes the role of vocabulary within the learning process. Third, we aim to outline the theoretical foundations, and empirical evidence for, two cognitive mechanisms that offer explanations of how knowing a spoken word might assist with the process of learning to read it. One cognitive mechanism, termed *set for variability* (Venezky, 1999) or *mispronunciation correction* (Dyson et al., 2017), is thought to operate from the point of visual exposure. Another mechanism, termed the *orthographic skeleton* (Wegener et al., 2018), is thought to exert an influence on written word learning that begins to operate before the reader has had any visual experience with a known spoken word. It is our position that these explanations

offer complementary rather than competing accounts of the relationship between spoken word and written word knowledge. Finally, we will conclude the review with suggestions for how the field might move forward.

1. Why might oral vocabulary be related to word reading development?

Although there are substantial individual differences in the size of children's oral vocabularies throughout development, estimates suggest that by the time children are in Grade 1, on average they are familiar with the spoken form of approximately 3100 root words (Anglin et al., 1993). Consequently, during their early school years, children will encounter in writing for the first time many words that are already familiar to them in spoken form (Chall, 1987). Observations of this nature highlight the developmental precedence of oral language, and provide an important impetus for work on the link between spoken and written word knowledge.

2. Relevant dimensions of spoken and written words

Before examining the evidence for a role of oral vocabulary knowledge within the process of learning to read new words, it is important to define two key dimensions of spoken and written words that recur within this literature (see also *Figure 1*).

As already alluded to, oral vocabulary comprises two separate but closely related aspects of knowledge. The basic distinction between pronunciation and meaning knowledge has been highlighted as an important consideration for understanding the role of oral vocabulary in reading acquisition because these aspects of spoken words may not be equally represented in the reader and may exhibit different relationships with reading outcomes (Nation & Cocksey, 2009; Ouellette, 2006; Ouellette & Beers, 2010). Indeed, familiar spoken word forms may be associated with variable knowledge of word meanings. For instance, children may possess rich, elaborated semantic representations for some words that are

familiar in spoken form while having no, or only partial, knowledge of the meanings of others.

The distinction between knowledge of the pronunciation and meaning of spoken words features prominently in assessment tasks. Pronunciation knowledge is sometimes referred to as lexical phonology (i.e., the sound patterns of words, Nation & Cocksey, 2009), or alternatively as oral vocabulary breadth (Ouellette, 2006). Pronunciation knowledge can be assessed using a range of tasks, such as spoken word-picture matching, picture naming or spoken word recognition tasks[1]. These assessments are intended to capture information about the number of familiar spoken word entries within the mental lexicon. Meaning knowledge is sometimes referred to as semantics, or oral vocabulary depth (Ouellette, 2006), and is typically measured with tasks assessing the connection between phonology and semantics. Such assessment methods require participants to provide spoken definitions of words or to match a spoken word with a picture depicting its meaning. Assessments of semantic knowledge are intended to capture the extent and quality of spoken word entries within the mental lexicon.

Another important distinction when considering the role of oral vocabulary within word reading concerns the print-to-pronunciation regularity of written words. It is well known that the English orthography contains substantial variability in the pronunciation of graphemes. This variability is observed in consonant pronunciations but is especially marked for vowel pronunciations (Carr & Pollatsek, 1985). For example, the consonant grapheme *ch* can be pronounced as in *chop* or *chef*, while the vowel grapheme *ea* can be pronounced as in *bleak, head* or *break*. When words contain the most common pronunciation for each grapheme they are regarded as regular for reading (e.g., *chop* and *bleak*), whereas words

[1] Nation and Cocksey (2009) suggest that only spoken word recognition tasks strictly assess knowledge of word pronunciations independent of any links with semantics.

containing one or more grapheme pronunciations that differ from the most common pronunciation are considered irregular for reading (e.g., *chef*, *head* and *break*). As such, print-to-pronunciation regularity is a binary distinction between regular and irregular words[2]. Print-to-pronunciation regularity is known to influence word reading, most notably manifesting in longer reading latencies for low frequency irregular words (Seidenberg et al., 1984). In the context of understanding the role of oral vocabulary within word reading, print-to-pronunciation regularity is of relevance because some models of word reading (e.g., Coltheart et al., 2001; Plaut et al., 1996) predict that semantic knowledge may be differentially associated with regular and irregular word reading. Specifically, semantic knowledge is thought to be more important for the reading of words containing irregular, compared to regular, mappings between graphemes and phonemes. This is because inconsistencies in grapheme-to-phoneme mappings mean that phonological decoding is not sufficient to access the correct pronunciations of these exception words (for discussion, see: Dawson & Ricketts, 2017; Ricketts, Nation, & Bishop, 2007; Taylor, Duff, Woollams, Monaghan, & Ricketts, 2015).

3. Evidence for the existence of an association between oral vocabulary and word reading

The link between spoken and written word knowledge has been investigated using a range of research designs, with each testing a specific hypothesis about the relationship between oral vocabulary and word reading (see *Figure 2*). Critically, these hypotheses vary in terms of their informativeness regarding the presence or absence of causal effects (Hulme &

[2] Print-to-pronunciation regularity is one method of describing variability in the mappings between orthography and phonology. Another method is the measurement of a word's *consistency*. When applied to reading, consistency describes the predictability of grapheme-to-phoneme correspondences. It is sometimes employed as a binary measure, but is more often used continuously, with a theoretical range of zero to one. When employed as a continuous measure, consistency refers to the proportion of all words with the same graphemes that share the pronunciation. Regularity and consistency are different approaches to capturing the complexities of writing systems.

Snowling, 2013). In the following section, we summarise evidence drawn from cross-sectional studies of individual differences, item-level analyses, longitudinal studies, and training study designs. At each stage, we highlight the hypothesis being tested by the research design and the extent to which it is informative regarding causation.

3.1 Cross-sectional studies of individual differences

Most cross-sectional studies of individual differences have computed by-participant correlations between standardised measures of oral vocabulary knowledge and word reading, thereby providing evidence for the existence of a general relationship between these skills (Ricketts et al., 2016). Using such methods, it has long been acknowledged that children who know more spoken words also tend to be better at word reading. Meta-analytic estimates, for instance, suggest the correlation between the two skills is in the moderate range (Scarborough, 2001).

More recent work has differentiated between aspects of oral vocabulary knowledge (breadth and depth) and word reading proficiency (regular and irregular). Measures of oral vocabulary breadth are usually associated with both regular and irregular word reading, though the latter relationship tends to be stronger (Bowey & Rutherford, 2007; Goff et al., 2005). A similar pattern has also been observed when vocabulary breadth is entered into regression analyses while controlling for other reading-related skills (Ouellette, 2006; the 6th Grade sample reported by Ouellette & Beers, 2010).

Measures of oral vocabulary depth have also been associated with children's reading attainment. Nation and Snowling (2004), for example, found that 8-year-old children's semantic knowledge accounted for unique variance in their word recognition scores, even when decoding and phonological skill were taken into account first. In studies that have distinguished between regular and irregular word reading, there is some evidence that the latter is more strongly associated with semantic knowledge than the former. Ricketts, Nation

and Bishop (2007), for example, tested a sample of 8 to 9-year-old children and found that semantic knowledge was associated with irregular, but not regular word reading. A similar pattern was reported by Ouellette and Beers (2010) in their sample of children in first grade. Taken together, cross-sectional studies of individual differences support the existence of an association between oral vocabulary (both breadth and depth) and reading, but imply the relationship may be stronger for the reading of irregular words.

In summary, cross-sectional studies of individual differences have concentrated on person-level patterns of association between spoken and written word knowledge. While identifying oral vocabulary as a factor worthy of further investigation, findings arising from this research design are compatible with two possible interpretations. One interpretation is that the link between spoken and written language arises indirectly, because a particular child might be generally good at learning both spoken and written words. An alternative possibility is that the link might arise directly, because spoken word knowledge plays an active role in learning to read or because reading skill plays an active role in vocabulary growth. As such, this design is not informative regarding causation.

3.2 Item-level analyses

Item-level analyses have been applied in a small number of cross-sectional studies. This approach tests the hypothesis that spoken word knowledge is related to word reading directly, such that knowledge of a given spoken word is associated with an increased likelihood of correctly reading that specific word. Thus, item-level relationships are probed by relating an individual's knowledge of words in the oral domain with their ability to read those same words.

Nation and Cocksey (2009) were the first to adopt this item-level approach. In their study, 7-year-old children completed three tasks at one-week intervals. Children first heard spoken words and indicated whether they recognised the pronunciations; next, they defined

the words; finally, they read the words aloud. By separately assessing spoken word recognition and meaning knowledge, the authors were able to distinguish between knowledge of pronunciations and meanings. When the same words were later presented for the children to read, half of the items were regular for reading while the others were irregular. The results suggested that if a word was familiar in spoken form, it was more likely to be read accurately than unknown spoken words. Children's knowledge of pronunciations was more strongly related to word reading accuracy than knowledge of word meaning, and the link between spoken and written word knowledge was larger for irregular than regular words.

Ricketts and colleagues (2016) included analyses of both person-level and item-level relations between oral vocabulary knowledge and word reading, but for the purpose of this review we will focus on their item level analyses. Working with a sample of 6- and 7- year-old children, the authors distinguished between pronunciation and meaning knowledge; between reading in isolation and reading in context; and between regular and irregular word reading. Their results revealed that both regular and irregular word reading were associated with oral vocabulary knowledge at the level of individual words. Compared to reading words in isolation, embedding words in meaningful sentence contexts benefited the reading of irregular words more than regular words. Additionally, and contrary to findings reported by Nation and Cocksey (2009), the ability to provide word definitions was more strongly related to reading accuracy than knowledge of lexical phonology.

Kearns and Al Ghanem (2019) reported data from children in Grades 3 and 4 using an analytic approach that related polysyllabic word reading accuracy to participants' item-specific semantic, orthographic and phonological knowledge (Model 1). Three additional analyses combined item-specific knowledge and person-level skills within the same model (Models 2, 3A and 3B), but we again focus here only on the item-specific analysis. Items consisted of 48 polysyllabic words which varied with respect to their print-to-pronunciation

consistency (as defined in Footnote 2). Item-specific orthographic knowledge was tested using a spelling recognition task, semantic knowledge was assessed using a task requiring children to recognise whether a word was used correctly or incorrectly, and phonological knowledge was assessed using a task requiring children to blend spoken syllables into correct pronunciations of the target words. The latter task merits a specific mention as it arguably taps a more general phonological skill than pronunciation recognition tasks. Nevertheless, children's reading accuracy was predicted by their performance on each of the three tasks tapping word-specific knowledge, suggesting the existence of direct relationships between children's word reading accuracy and their item-specific orthographic, semantic and phonological knowledge.

In summary, item-level analyses converge on the view that there is a direct relationship between children's oral vocabulary knowledge and their word reading. However, the relative roles of lexical phonology and semantics within this relationship are less clear: of the three studies of this type, one (Nation & Cocksey, 2009) gives weight to the role of lexical phonology, while two suggest an additional role for semantic knowledge (Kearns & Al Ghanem, 2019; Ricketts et al., 2016). While the existence of a direct relationship between oral vocabulary and word reading is compatible with the possibility that the relationship might be causal, as a correlational design, it cannot establish that it is.

3.3 Longitudinal studies

Longitudinal studies employ individual differences in an early measured skill to predict later performance on another task, thereby identifying factors that could plausibly make a causal contribution to skill development.

Infant studies: While infant oral vocabulary skills have been shown to predict later language skills, there is a high degree of variability in vocabulary attainment during the early stages of development (Reilly et al., 2010). Supporting this view is the finding that many

children identified as late talkers during infancy subsequently present at school age with age-appropriate language scores, while others who present with typical language scores during infancy go on to meet criteria for language delay at school age (Rescorla, 2011). This lack of early stability in vocabulary scores presumably constrains the outcomes of studies that employ infant vocabulary scores to predict subsequent reading achievement. Nevertheless, a small but highly significant predictive relationship has been observed between infant oral vocabulary, as measured by parent report, and subsequent school-age word reading achievement. For example, Lee (2011) obtained parent oral vocabulary ratings at 24 months of age for a sample of more than 1,000 children and tracked their language and literacy skills between the ages of three and eleven years. Early oral vocabulary was a significant predictor of school-age literacy, accounting for approximately five percent of the variance in attainment. Similarly, Duff and colleagues (2015) obtained parent ratings of the oral vocabulary knowledge of 300 infants between the ages of 16 and 24 months. The children's vocabulary, phonological and reading skills were assessed an average of five years later. Infant oral vocabulary ratings were a highly significant predictor of subsequent reading accuracy, accounting for approximately 11% of the variance in outcomes.

School-age studies: Results of longitudinal studies addressing the issue of whether oral vocabulary measured during the school years predicts later reading achievement are less consistent. For instance, two studies with English-speaking children have yielded divergent findings. Nation and Snowling (2004) found that children's oral vocabulary knowledge as assessed at eight and half years of age accounted for unique variance in their word recognition scores at 13 years of age, even when decoding and phonological skill were taken into account first. However, Muter and colleagues (2004) investigated whether oral vocabulary as measured at school entry predicted reading achievement two years later and found no significant predictive relationship. Instead, the bulk of the variance was accounted

for by individual differences in letter knowledge and phoneme sensitivity. Another relevant study was conducted with Dutch-speaking children in Grades 1 to 6 (Verhoeven et al., 2011). These authors investigated bidirectional relations between oral vocabulary and word reading efficiency, asking whether vocabulary knowledge predicted word reading and whether word reading predicted vocabulary knowledge. The results suggested influences operating in both directions: vocabulary assessed in Grade 1 predicted word reading in Grade 2, while word reading in Grades 2 and 4 predicted vocabulary in Grades 3 and 5. Studies with Chinese speaking children, however, have produced a mixed pattern of findings, with some suggesting early measured vocabulary predicts later word reading (Yan et al., 2021), while others suggest that early measured word reading only predicts later vocabulary (Hulme et al., 2019).

In summary, oral vocabulary measured prior to the developmental emergence of reading appears to predict subsequent word reading achievement when children reach school. Infant studies suggest the presumed cause (spoken word knowledge) precedes the effect (the emergence of word reading), thereby identifying, but not establishing, that oral vocabulary could plausibly play a causal role in word reading development. However, longitudinal predictive relationships when both skills are measured during the school years (and when early reading scores are controlled for) are less reliable. While this could be viewed as challenging the suggestion that the relationship might be causal, a key methodological issue is worth noting. Longitudinal studies employ standardised assessments of oral vocabulary (breadth or depth) and word reading, but the words contained in these measures do not overlap. That is, oral vocabulary knowledge is tested for one set of words while reading accuracy or efficiency is tested using a distinct set of words. Thus, the analytic method asks whether knowing a given spoken word predicts reading of a different word. However, if word-specific knowledge is important for learning to read words, as suggested by studies

employing item-level analyses (Kearns & Al Ghanem, 2019; Nation & Cocksey, 2009; Ricketts et al., 2016), then general measures of oral vocabulary breadth and depth may be insensitive to these effects (Hulme & Snowling, 2013b).

3.4 Training studies

Training studies provide the most powerful evidence for the existence of causal effects (Hulme & Snowling, 2013a, 2013b; Nation & Castles, 2017). Thus, if oral vocabulary knowledge were causally related to word reading, this would be supported by studies showing that training in spoken word knowledge boosts reading accuracy for those words relative to untrained items. If separate conditions compare training in pronunciation knowledge with training in word meaning, then this permits the researcher to evaluate whether semantic knowledge conveys any additional benefit to word reading over and above knowledge of lexical phonology.

Developing readers: Three studies with developing readers have adopted a novel word training paradigm to investigate the influence of oral vocabulary knowledge on reading performance[3]. This approach provides an analogue for the experience, common in the early stages of learning to read, of encountering a familiar spoken word in print for the first time. Over 40 years ago, Hogaboam and Perfetti (1978) taught Grade 4 children either the pronunciations alone, or the pronunciations and meanings, of a small set of novel spoken words. Following training, children saw all the trained words for the first time in writing along with another set of untrained items that were entirely new. Children read aloud all items, both trained and untrained. Reading aloud latencies were shorter for all orally trained items, consistent with prior oral vocabulary knowledge benefiting performance at the first reading encounter. Over 20 years later, McKague, Pratt and Johnston (2001) used a similar

[3] Novel word stimuli serve two main purposes. First, their use ensures that participants cannot have any pre-existing knowledge of them, thus providing tight experimental control over the knowledge that children bring to this task. Second, their use permits tight experimental control over stimulus properties (e.g., number of phonemes, number of letters, predictability of mappings between graphemes and phonemes).

approach with children in Grade 1. The children were taught either the pronunciations alone, or the pronunciations and meanings of a set of novel words. At test, children read aloud the trained novel words and a set of untrained items. Reading aloud accuracy was better for orally trained than untrained items, with an accuracy advantage of almost 30%. Duff and Hulme (2012b) similarly taught children aged approximately 6 years of age either the pronunciations and meanings, or only the pronunciations, of a set of novel words while another set were untrained. They too found an accuracy advantage for the orally trained over the untrained items. None of these studies with developing readers found evidence that semantic knowledge conveyed any additional benefit to reading accuracy or efficiency over knowledge of the phonological form alone.

Skilled readers: In an artificial orthography learning paradigm, Taylor et al. (2011, experiment 2) pre-exposed adults to either the phonology alone, or the phonology and meanings of a set of items that varied in both frequency and vowel consistency, and compared reading of these items with reading of untrained items. Early in training, both lexical phonology and semantic pre-exposure facilitated reading accuracy, regardless of frequency or consistency, and there was no additional advantage observed for semantically trained items. However, by the end of training, pre-exposure to semantics improved reading accuracy for items with low frequency inconsistent vowels whereas lexical phonology did not confer a reading accuracy advantage compared to untrained items.

In summary, training studies with developing and skilled readers converge on the view that prior oral vocabulary knowledge makes a causal contribution to subsequent reading accuracy and efficiency, although the role of meaning within this process remains less clear. Work with developing readers suggests that pronunciation knowledge, rather than knowledge of meaning, drives the advantage of orally trained over untrained words on subsequent measures of reading performance (Duff & Hulme, 2012a; Hogaboam & Perfetti, 1978;

McKague et al., 2001). However, this contrasts with conclusions drawn on the basis of an artificial orthography study with adults in which word regularity and reading experience were taken into account (Taylor et al., 2011).

4. How do theories of orthographic learning explain the role of oral vocabulary within word reading?

Oral vocabulary is generally thought to assist with the process of acquiring representations of written words that support rapid and accurate word recognition, or *orthographic learning* (Castles & Nation, 2006; Nation & Castles, 2017). Here, we outline major theories of reading development and orthographic learning, each of which offer predictions about the role oral vocabulary knowledge plays within reading acquisition.

4.1 Ehri's stage theory of reading development

Ehri (1992, 2005, 2014) proposed that as children learn to read they progress through a series of phases across developmental time. The phases are named to reflect the main types of connections children form to assist them to remember how to read words. The earliest stage of reading development occurs largely prior to formal reading instruction. It is referred to as *pre-alphabetic* because, due to a lack of knowledge about the writing system, children tend to rely on prominent visual features to read a very small number of written words. When children acquire some limited knowledge of letter names or sounds, they enter the *partial alphabetic phase* in which this knowledge is employed to make connections between some letters and sounds in printed words. Not all letters will be accompanied by a pronunciation in this phase because children's knowledge of letter-to-sound correspondences and their appreciation of the sound structure of language are limited. When knowledge about grapheme-to-phoneme correspondences is sufficient to permit children to make complete connections between the letters in printed words and the sounds with which they are associated, they enter the *full alphabetic phase*. In this phase, children are thought to employ

several reading *strategies*. Prominent among these is a decoding strategy in which graphemes are converted to phonemes and then blended to form a word. Use of this strategy is thought to permit children to map a spelling pattern onto a pronunciation. This serves, through repeated encounters with the written word form, to permit children to begin to build a store of *sight words*, or words that can be read rapidly without recourse to the slow process of phonological decoding. The final stage is the *consolidated alphabetic stage*, which occurs when there is an accumulation of sight words held in memory. Sight word acquisition accelerates in this phase because children can draw on their existing knowledge to identify recurring letter patterns which then become consolidated into multi-letter units representing specific phonological blends. These larger units take the form of grapho-syllabic and morphemic spelling-sound units such as, for example, *–ump, -in, -and, -er, -ed* and *–ing*. Units of this type are thought to benefit reading acquisition because they reduce the number of connections a reader needs to form in order to store a word in memory.

Orthographic learning as conceptualised elsewhere (Castles & Nation, 2006; Nation & Castles, 2017) occurs in the full alphabetic stage and particularly in the consolidated alphabetic stage. Ehri (2014) theorised that for an orthographic representation to be formed, *orthographic mapping* must occur, a process thought to be largely driven by phonological decoding. Orthographic mapping refers to the process of forming connections between aspects of lexical representation, and is initiated when a reader encounters a new printed word and then either attempts to produce the spoken word or hears its pronunciation. When this occurs, the spelling of the word is thought to become mapped onto its pronunciation and meaning. These mapping connections between lexical representations of form are proposed to "glue" spellings to their pronunciations in memory. Oral vocabulary knowledge is viewed as assisting within this process in two ways. First, processing the meanings of words is thought to connect semantic information to word units. And second, immediately following

phonological decoding, the child attempts to match the outcome of their decoding attempt to a known spoken word that is also consistent with the context in which it appears.

4.2 Self-teaching hypothesis

Rather than describing the process of learning to read as unfolding in a series of phases across developmental time, Share (1995) proposed that children acquire orthographic representations at an item level[4]. Explanations of orthographic learning that focus on the item level are advantageous as they readily account for the observation that novel written words will be acquired throughout the lifespan. According to the self-teaching hypothesis (Share, 1995, 1999, 2004, 2008), the chief means by which orthographic learning occurs is via a process of phonological decoding. When a child is able to apply their knowledge of grapheme-to-phoneme correspondences, they have the potential to deduce the pronunciation of newly encountered written words. Whenever phonological decoding produces a correct pronunciation, this is thought to provide the child with an opportunity to learn its spelling. Ultimately an orthographic representation of that word is generated that facilitates future rapid and accurate retrieval of its phonology and meaning. While orthographic learning can occur very rapidly (Share, 2004), perhaps even following a single encounter with a novel written form, the self-teaching hypothesis favours the view that word recognition and orthographic learning should depend, at least in part, on the frequency with which it has been seen.

The self-teaching hypothesis conceives of oral vocabulary knowledge as providing assistance within the process of linking orthographic and phonological word forms (Share, 1995, 2008). A child may achieve only a partial or erroneous phonological decoding of a novel printed word, either because they possess inadequate knowledge of grapheme-to-phoneme correspondences or because the word contains irregularities in these mappings. Oral

[4] On this account, each written word is considered to be an "item" which must be individually acquired.

vocabulary is thought to confer a particular advantage in these instances because the failure to arrive at a known pronunciation should prompt the child to revise their initial phonological decoding attempt in an effort to align it with a phonologically similar known word. The availability of contextual information is thought to facilitate this post-hoc matching process (Share, 2008).

4.3 The lexical quality hypothesis

The lexical quality hypothesis (Perfetti, 1992, 2007; Perfetti & Hart, 2002) is another item-specific theory of orthographic learning that provides a useful framework for conceptualising word representations. According to this view, lexical representations consist of three components – the orthographic form, the phonological form and semantics – each of which can vary in quality. In an early iteration of the theory, Perfetti (1992) described two key principles that characterise the development of lexical quality: *precision* and *redundancy*. A lexical form is said to be precise when it accurately encodes an exact spelling such that a given sequence of letters can be recognised rapidly via direct lexical access and distinguished from other visually similar words. For example, the orthographic representation of *from* is fully specified when it can be distinguished from the spelling *form* or *frog*. A lexical representation is said to have the property of redundancy when there are multiple connections between the orthographic form, the phonological form and semantics. Together these connections serve to bind the three aspects of representation, thereby assisting visual word recognition. The properties of precision and redundancy are assumed to emerge upon visual exposure to an orthographic form (Perfetti, 1992), and to improve in quality with repeated encounters with the written form (Reichle & Perfetti, 2003).

The lexical quality hypothesis views the presence of oral vocabulary knowledge as assisting children to form and strengthen links between phonological and orthographic representations. Additionally, it predicts that when lexical quality is low, reliance on

vocabulary knowledge should increase. Lexical quality might be low for a number of reasons. For example, irregularities in the mappings between letters and their pronunciations can weaken connections between orthography and phonology, thereby reducing lexical quality. Alternatively, lexical quality might be low because an aspect of lexical representation is absent or degraded in some way.

In summary, although there are differences in the specifics of how the role of oral vocabulary within reading is conceived within theories of orthographic learning, common to each is the assumption that oral vocabulary knowledge supports word reading from the point at which a new written word is seen in print.

5. A mechanism that operates from the point of visual exposure

The basic idea that oral vocabulary might benefit word reading accuracy from the point of visual exposure predates modern theories of orthographic learning. Over 50 years ago Gibson (1965) proposed the concept of *set for diversity*. Its original conceptualisation and a more modern iteration called *set for variability* (Venezky, 1999) both suggest that phonological decoding attempts will frequently result in a reader arriving at an unknown pronunciation. When this occurs, the reader is prompted to consciously attempt to adjust their pronunciation until they find one that matches a known word in their oral vocabulary and makes sense within the context. Early theorists largely discussed this matching process in the context of irregular word reading, because phonological decoding should typically[5] not result in a recognisable pronunciation, so the requirement to adjust an assembled pronunciation is obvious. The assumption that set for variability is most relevant for irregular words has been echoed more recently (e.g., Dyson, Best, Solity, & Hulme, 2017; Tunmer & Chapman, 2012;

[5] However, there will be some instances in which phonological decoding of an irregular word produces a known pronunciation that is in fact an incorrect reading of the written word. For instance, the written word *sweat* is phonologically decoded as /swi:t/, which matches the pronunciation of the written word *sweet*. The words sweat and sweet are potentiophones. In this instance, without the benefit of contextual support, no significant adjustment to the pronunciation is likely.

Zipke, 2016), while others have argued such a process operates even during regular word reading because assembled pronunciations for these words still require some, albeit smaller, adjustment for matching to occur[6] (Elbro et al., 2012; Kearns et al., 2016; Savage et al., 2018).

Studies investigating set for variability have typically conceived of it as a person-level skill reflecting the flexibility with which children can match a mispronounced spoken word with its correct pronunciation. Tests of this ability require children to provide the correct pronunciation when presented with the spoken regularised pronunciations of irregular written words (e.g., "*watch*" pronounced as if it rhymes with *match,* Elbro et al., 2012; Kearns et al., 2016; Tunmer & Chapman, 2012).[7]

Several distinct research designs have been employed to investigate the association between the ability to perform mispronunciation corrections and word reading. For instance, in a cross-sectional study of individual differences within a sample of Dutch-speaking Grade 1 children, Elbro and de Jong (2012, Study 1) found that the ability to link inaccurate pronunciations with real words was a significant predictor of both regular and irregular word reading, even after controlling for other reading related skills. Similar results have also been reported with older (7 to 11-year old) English-speaking children (Kearns et al., 2016).

Using a different approach, Steacy and colleagues (2019) combined item-level, person-level and word-level predictors into the same analytic model using data from children in Grades 2-5. We will focus here on the item level analyses but refer the reader to the paper for details of the person and word level analyses. The outcome measure was children's item level accuracy when reading aloud the 40 irregular words from Tunmer and Chapman's

[6] This proposed phenomenon avers that a blended pronunciation such as /k/+/æ/+/t/ is not phonologically identical to uttering the whole word /kæt/ as a single unit. Therefore the blended pronunciation requires some (minimal) form of matching to the known spoken word.
[7] The reader is referred to Edwards and colleagues (2021) for an insightful discussion and investigation of the child- and word-level characteristics that influence performance on the mispronunciation correction task.

(2012) mispronunciation correction task. Children also completed the mispronunciation correction task orally as a measure of the ability to resolve discrepancies between mispronunciations and known spoken words. Thus, children's accuracy on the oral mispronunciation correction task could be used to predict their reading accuracy for the same words. Findings suggested that if a child corrected the pronunciation of a word in the oral task there was a reading accuracy advantage for those words, compared to items that were answered incorrectly on the oral mispronunciation task. These findings support the existence of a direct item-level relationship between oral mispronunciation correction ability and the ability to read the same set of irregular words.

Two longitudinal studies have reported significant associations between mispronunciation correction ability measured at an early time point and subsequent word reading outcomes. For instance, Tunmer and Chapman (2012) reported that set for variability measured in Grade 1 predicted both word reading and decoding concurrently in Grade 1 and longitudinally in Grade 3. Elbro and de Jong (2012, Study 2) reported similar findings in a longitudinal study with Dutch-speaking children who were followed from preschool into Grade 1 at school.

Four intervention studies have used a different approach: children were taught to recognise their inaccurate phonological decoding attempts and were provided with explicit instruction regarding how their mispronunciations might be adjusted. Three of these intervention studies occurred over a brief timeframe (Colenbrander et al., 2022; Dyson et al., 2017; Zipke, 2016). Each concluded that while training improved children's ability to modify their pronunciations relative to the control group, the benefit did not appear to generalise to untreated items. A longer-term training study with at-risk readers provided explicit instruction in mispronunciation correction alongside intensive teaching of grapheme-to-phoneme correspondences and found clear evidence of a general intervention benefit on

untreated materials (Savage et al., 2018). The use of multiple intervention components in the latter study, however, makes it difficult to draw conclusions regarding the locus of the benefit.

Using a novel word training study design, Murray and colleagues (2022) did not explicitly teach their participants to use a mispronunciation correction strategy. Rather, they sought to establish whether this process is spontaneously used by children as they encounter irregular written words in print for the first time. English-speaking Grade 5 children were first taught the pronunciations and meanings of a set of novel spoken words while another set were untrained. The items were subsequently embedded in either contextually neutral or supportive sentences, and children's eye movements were recorded as they read independently. The spellings of the written words were selected so that there was either a regular relationship between the spoken word and written word form (e.g., "*vaik*" written as *vake*), or an irregular relationship (e.g., "*vaik*" written as *vike*). When words had been orally trained and then shown with irregular spellings, fixation durations were longer than those observed on words that had been orally trained and then then shown with regular spellings. Because children likely first computed a regularised pronunciation of the orally known irregular items, which did not match the taught pronunciation, the authors argued that the longer processing times for irregular items reflected the operation of a process in which this initial decoding attempt was adjusted in an attempt to reconcile it with the known spoken form. Additionally, there was also an effect of context on total reading times such that there was a larger difference in looking times between irregular and regular words presented in contextually supportive sentences than those presented in neutral sentences. This was interpreted as suggesting that the semantic support provided by contextual sentences may have provided an additional prompt for children to adjust their initial phonological decoding attempt.

In summary, these findings establish set for variability (or mispronunciation correction) as a plausible cognitive mechanism through which oral vocabulary knowledge might support children to learn to read new words. Importantly, this mechanism is proposed to operate from the point of visual exposure to a written word, after an initial assembled pronunciation has been derived from phonological decoding.

6. A mechanism that operates prior to visual exposure

Each of the accounts discussed thus far have proffered the view that spoken word knowledge should assist children to make mappings between written words and their pronunciations. As such, each predicts that spoken word knowledge begins to influence written word learning upon visual exposure to the printed form. An alternative possibility is that spoken word knowledge may actually exert an effect on word reading that commences prior to visual exposure, via the ability to translate from pronunciation to print. This possibility was initially raised by Stuart and Coltheart (1988) but was not tested. Their suggestion was that a child who could segment spoken speech sounds and had reasonable knowledge of the mappings between letters and sounds could potentially begin to develop a store of orthographic representations prior to commencing formal literacy instruction.

6.1 Orthographic influences on spoken word processing

The viability of hypotheses proposing that orthographic representations may begin to be generated prior to visual exposure depends upon the existence of bidirectional interactivity between written and spoken language. Major models of visual word recognition include bidirectional connections between orthography and phonology, thereby acknowledging phonological influences in visual word recognition (e.g., Coltheart et al., 2001; Plaut et al., 1996). This implies, by extension, that there may be symmetry within the language system whereby orthography may influence spoken word processing. In line with this proposition, there now exists a body of evidence, largely based on skilled readers but also drawn from

work with developing readers, that orthographic information is activated during the processing of spoken words (for a review, see Taft, 2011).

Experiments that explore the influence of orthographic knowledge on spoken word processing exploit differences between words in terms of the consistency of their spellings. In this context, consistency refers to the degree to which a spelling can be predicted from the phonological form of a word (Stone et al., 1997). The term consistency can also be used to refer to the degree to which a pronunciation can be predicted from the orthographic form of a word. Consistency is therefore a feature of the relationship *between* spoken words and written forms that is present bidirectionally – from pronunciations to written forms (as in spelling) and from written forms to pronunciations (as in reading).

Consistency can be defined at multiple levels of representation; the word level, the rime-body level and the phoneme level (Van Orden & Kloos, 2005) but is most frequently discussed at the level of the rime-body. When a word body is always pronounced the same way, such as *_ing* as in *bring,* it is referred to as consistent for reading; and when a pronunciation body is always written in the same way, such as *_ing* in *bring,* it is referred to as consistent for spelling. The word *bring* is therefore consistent for both reading and spelling. When a word body can be pronounced in more than one way, such as *_amp,* as in *stamp* and *swamp*, it is considered to be inconsistent for reading (written form to pronunciation); and when a pronunciation is associated with more than one plausible spelling pattern, as in the words *team, deem* and *theme*, it is considered to be inconsistent for spelling (pronunciation to written form).

As alluded to earlier, differences in consistency have been used to explore the notion that an individual's knowledge of orthography penetrates their spoken word processing. The hallmark of this effect is slower responding to words with inconsistent spellings, such as *theme*, than words with consistent spellings, such as *bring*, during auditory lexical decision

tasks. This effect has repeatedly been found among skilled readers (Pattamadilok et al., 2007, 2009; Perre et al., 2009; Petrova et al., 2011; Ziegler et al., 2004, 2008; Ziegler & Ferrand, 1998) and initial evidence suggests it is also observable in developing readers (Ventura et al., 2007, 2008). Alternative experimental paradigms offer converging evidence for automatic activation of orthography during spoken word processing. For example, using an auditory lexical decision task Chéreau and colleagues (2007) found that while phonological overlap (*hurt-dirt*) facilitates processing, orthographic overlap (*shirt-dirt*) provides an additional facilitatory boost to word recognition. A similar effect has been found using pseudohomophone priming – responses to words in an auditory lexical decision task were facilitated when preceded by a pseudoword that could be spelled in the same way as the target (Taft et al., 2008). That is, hearing the spoken pseudoword prime /trʌθ/ facilitated subsequent processing of the target word /tru:θ/. These data, together with those of McKague and colleagues (2008), imply the existence of a mechanism that permits oral vocabulary knowledge to influence word reading prior to visual exposure is plausible.

6.2 Could oral vocabulary influence word reading prior to visual exposure?

Initial data from skilled readers is consistent with the notion that oral vocabulary knowledge could influence reading prior to visual exposure. For example, Johnston et al. (2004) taught skilled readers the pronunciations of a set of highly obscure real words. When later encountered in the context of a masked priming task, lexical decisions to the orally trained words exhibited a pattern of facilitation that was commensurate with that observed for familiar written words whereas untrained novel words did not. This finding, which suggests that trained novel words were responded to as if they were familiar words is potentially consistent with the interpretation that representations of the trained novel words had begun to be established prior to visual exposure. McKague et al. (2008) found a similar pattern of masked priming effects for orally trained words at their first visual exposure, consistent with

the idea that training in the phonology and semantics of novel words permitted automatic access to partially specified orthographic representations of those words.

7. Orthographic skeletons

On this background, Wegener and colleagues (2018) proposed the *orthographic skeleton hypothesis*. This account suggests that when a child holds a word in their oral vocabulary, and when that child also has knowledge of the mappings between phonemes and graphemes, they may form an expectation of the likely spelling of that word even if it has not yet been encountered in print. Two experiments with children in Grade 4 (Wegener et al., 2018, 2020) tested this idea directly. Children were first taught the pronunciations and meanings of a group of spoken words in short sessions over four days. Subsequently, the children read both trained and untrained novel words embedded in contextual sentences while their eye movements were recorded. When orally trained novel words were later shown with predictable spellings (e.g., the spoken word "nesh" was written as *nesh*), processing times were shorter than for orally trained words with unpredictable spellings (e.g., the spoken word "coib" was written as *koyb*). Critically, the difference in fixation durations between items with predictable and unpredictable spellings was larger for orally trained novel words than orally untrained items. This interaction was interpreted as suggesting that online processing is facilitated when there is a match between the reader's spelling expectation and the actual orthographic form; whereas, there is a processing cost when there is a mismatch between expectancy and form. As such, these findings were interpreted as being consistent with the operation of a mechanism causally implicated in word reading that begins prior to visual exposure.

The first visual exposure to orally trained and untrained items is thought to be particularly informative with respect to the question of whether readers form orthographic expectations on the basis of their spoken word knowledge. This is because influences arising

from phonology-to-orthography connections are likely to be strongest at the first visual exposure, whereas reading experience gained via multiple visual exposures to a written word allow influences arising from orthography-to-phonology connections to grow (McKague et al, 2008). On this basis, Wegener and colleagues (2020) hypothesised that increasing visual experience with novel written words would allow their Grade 4 participants to update their spelling expectancies. This is indeed what was found, with the orthographic skeleton effect being observed at the first and second, but not the third, visual exposure. This finding was interpreted as suggesting that the children initially formed spelling expectations of orally trained novel words, which they were then able to update on the basis of their visual experience. Thus, orthographic skeletons are tentative representations of written words that are either confirmed or disconfirmed by visual experience with written word forms.

Building on this, Beyersmann and colleagues (2021) used a procedure adapted from Wegener and colleagues (2018) to investigate whether skilled readers could form orthographic skeletons of novel embedded stems during spoken word training. To this end, adults were taught the pronunciations and meanings of a set of novel morphologically complex words (e.g., “neshing”, “neshed”, “neshes”) while another set were untrained. Subsequently, participants saw the printed form of the novel word stems for the first time (e.g., *nesh*), embedded in sentences, and their eye movements were monitored. Half of the stems had predictable spellings, while half had unpredictable spellings. Fixation durations revealed the same pattern of findings as observed in the child studies (Wegener et al., 2018, 2020), thereby suggesting that the adults had formed orthographic expectations of embedded stems during spoken word learning.

Converging evidence for this mechanism has recently been reported among skilled readers of Spanish. In a web-based experiment, Jevtović and colleagues (2022) taught native Spanish speakers the pronunciation of a set of novel spoken words paired with picture

referents. Subsequently, participants encountered the trained items and a matched set of untrained items in print in the context of a self-paced reading task. Spanish is a transparent orthography in which there is a high degree of consistency in mappings between phonemes and graphemes: most phonemes in Spanish can be represented by just one grapheme (e.g., the phoneme "p" can only be written as *p*); whereas a few speech sounds can be represented by one of two possible graphemes (e.g., the phoneme "b" can be written as either *b* or *v*). Drawing on this observation, their experiment had three spelling conditions. Consistent items were novel words with only one possible spelling, whereas inconsistent items had two possible spellings. Using a spelling pre-test, the authors established participants' idiosyncratic spelling preferences for the inconsistent items. At the point of reading the words for the first time within the self-paced reading task, participants were shown half of the inconsistent items in their preferred spelling, while the other half of the inconsistent items were shown in their non-preferred spelling. The results showed longer reading times for the inconsistent unpreferred condition compared to the consistent and inconsistent preferred conditions, but only for items that had been orally trained. In contrast, reading times for untrained items with consistent, inconsistent preferred, and inconsistent unpreferred spellings, did not differ. This pattern of findings was interpreted as evidence that participants had formed orthographic skeletons for the trained items, which influenced processing times when there was a mismatch between expectation and form.

In summary, there is emerging evidence that readers can generate orthographic expectations of the written form of orally known words. As such, this cognitive mechanism suggests that oral vocabulary knowledge begins to exert an influence on learning to read new words that commences prior to the first visual exposure. This cognitive mechanism is observed early in children's experience with written words (at the first and second visual exposure), after which visual experience updates these nascent orthographic representations.

Skilled readers also show this effect, suggesting that orthographic skeletons might operate across the spectrum of reading skill.

8. Conclusions and future directions

There is an established association between oral vocabulary and word reading such that children with larger oral vocabularies also tend to be better readers (Scarborough, 2001). This association is borne out in a range of study designs, including cross-sectional studies of individual differences (Goff et al., 2005; Ouellette, 2006; Ouellette & Fraser, 2009; Ricketts et al., 2007), item-level analyses (Kearns & Al Ghanem, 2019; Nation & Cocksey, 2009; Ricketts et al., 2016) and longitudinal studies (Duff et al., 2015; Lee, 2011). Outcomes of these studies suggest oral vocabulary could plausibly play a causal role in the development of word reading, but cannot establish that it does. Training studies in which children are taught the spoken form of novel words before encountering them in print for the first time show that this prior knowledge conveys an accuracy and efficiency advantage over unknown words when they are first seen in print (Duff & Hulme, 2012b; Hogaboam & Perfetti, 1978; McKague et al., 2001), thereby establishing a causal role for oral vocabulary knowledge within the process of learning to read new words.

Existing theories of orthographic learning view oral vocabulary as exerting an influence on written word learning that commences upon exposure to a written word (Ehri, 1992, 2005, 2014; Perfetti, 1992, 2007; Perfetti & Hart, 2002; Share, 1995, 2008). This fact is noteworthy because the two cognitive mechanisms that have been proposed to explain how oral vocabulary influences word reading differ with respect to the proposed timing of the effect.

One mechanism, termed *set for variability* (Gibson, 1965; Venezky, 1999) or *mispronunciation correction* (Dyson et al., 2017), is proposed to exert an effect on written word learning that begins from the point in time that a word is seen in print. On this view,

when phonological decoding of a word results in an assembled pronunciation that does not match any words held within oral vocabulary, this mismatch prompts the reader to adjust their pronunciation in order to align it with a spoken word they do know. Although accounts of this cognitive mechanism have their genesis in writings that are more than 50 years old (Gibson, 1965), research on this topic has only recently begun to accumulate. Cross-sectional studies of individual differences and item-level analyses are compatible with the view that set for variability influences word reading (Elbro et al., 2012; Kearns et al., 2016; Steacy et al., 2019; Tunmer & Chapman, 2012). A novel word training study suggests that adjusting assembled pronunciations is a process that is spontaneously used by children as they encounter irregular written words in print for the first time (Murray et al., 2022), while intervention studies suggest that providing explicit instruction to children regarding how to adjust their pronunciations may hold potential for improving reading outcomes (Colenbrander et al., 2022; Dyson et al., 2017; Savage et al., 2018; Zipke, 2016).

The second mechanism, termed *orthographic skeletons*, is proposed to exert an effect on written word learning that commences before words are seen in print for the first time (Wegener et al., 2018). On this view, when a child is familiar with the spoken form of a word and also appreciates how spoken speech sounds map onto written letters, they can draw on both sources of information to generate an expectation of the likely spelling of a word they have not yet seen in writing. This recently proposed cognitive mechanism has been investigated using novel word training studies: findings with English-speaking children and adults, and Spanish speaking adults, are all consistent with the operation of this cognitive mechanism (Beyersmann et al., 2021; Jevtović et al., 2022; Wegener et al., 2018, 2020). Importantly, this cognitive mechanism is thought to give rise to tentative orthographic representations that are rapidly updated as visual experience with a specific word grows (Wegener et al., 2020). Because existing theories of orthographic learning (Ehri, 1992, 2005,

2014; Perfetti, 1992, 2007; Perfetti & Hart, 2002; Share, 1995, 2008) all predict that oral vocabulary should only exert an effect on written word learning that begins from the point of visual exposure, as currently conceptualised, they cannot accommodate findings consistent with the operation of a cognitive mechanism that begins to influence word learning prior to visual exposure. In view of emerging evidence suggesting that readers can generate spelling expectations for orally known words before viewing them in writing, we suggest that theories of orthographic learning might reasonably be extended to accommodate the operation of this alternative cognitive mechanism.

On the basis of our review of the literature, we conclude that emerging evidence supports the operation of both cognitive mechanisms. We have stressed that *set for variability* operates from the point of visual exposure, whereas *orthographic skeletons* are formed on the basis of spoken word knowledge prior to exposure to the written word forms. We view these distinct cognitive mechanisms as offering complementary accounts of the association between spoken and written word knowledge: both may operate, but at different time points.

Future directions

Much progress has recently been made towards understanding how knowing a spoken word assists with the process of learning to read it. It is our view that many opportunities exist for building on our understanding of both cognitive mechanisms. We will outline just a few here.

Set for variability/mispronunciation correction: If the ability to adjust decoded pronunciations and match them with known spoken words benefits word reading, how is this best observed? For instance, are adjustments of computed phonology audible or inaudible? And does this characterisation differ across age and with reading skill? Those who have worked with children might have observed beginning readers making frequent self-corrections of computed phonology during read alouds (e.g., the written word *was* might be

decoded as "*wass*" before being corrected to "*woz*"), but our own anecdotal observations suggest that audible mispronunciation corrections seem less salient among older readers when they read aloud. This might be because children have a larger bank of orthographic representations to draw on during read alouds, meaning that fewer mispronunciations are generated. An additional possibility is that children might become more skilled at applying mispronunciation corrections during the reading process. On this view, older children and adults might engage in subvocal adjustments to computed phonology, which would see the process shift from being largely audible when beginning readers read aloud to being largely inaudible during reading aloud among children of increasing age and skill. Ideally, these ideas should be tested using novel word training studies so that there is tight experimental control over the lexical knowledge children bring to the task of reading.

Another issue worthy of further investigation is how mispronunciation correction ability is best tested. Currently, the key tests of this ability in English are all versions of the mispronunciation correction task (Tunmer & Chapman, 2012). Although this task occurs within the oral domain – mispronunciations are spoken and children must provide an oral correction – recent work suggests that the test might also involve connections between phonology and orthography (Edwards et al., 2021). The authors proposed that if a child hears a mispronounced word in the context of the oral mispronunciation correction task, and is explicitly able to imagine its spelling, they might be able to use this information to disambiguate its pronunciation. This is a very interesting idea about one way in which a child might be able to complete the mispronunciation task. This conceptualisation is noteworthy because it implies that this strategy should be most beneficial when the child already has an orthographic representation of the word in question. However, set for variability is thought to be a strategy applied to adjust phonological decoding attempts in order to match them with known spoken words. Its primary role is not generally conceived of as a means of locating

the pronunciation for written word forms when the orthographic representation has already been acquired. Rather, it is meant to assist the reader to find the correct pronunciation when the written word is not sufficient stimulus to rapidly access its phonology. Therefore, future research might explore additional approaches to measuring the facility with which a reader can flexibly adjust their decoded pronunciations. Further, it will be important to consider the role of semantics within these efforts.

Orthographic skeletons: Investigations of the orthographic skeleton with English-speaking children have all employed monomorphemic words (Wegener et al., 2018, 2020), yet monosyllables represent only a fraction of words in English (Mousikou et al., 2017). It has already been shown that adults, when trained in the inflected forms of morphologically complex words, are able to extract orthographic skeletons for the embedded stems (Beyersmann et al., 2021). In view of developing readers' emerging appreciation of the morphological structure of written language (Beyersmann et al., 2012; Dawson et al., 2018), it will be important to extend this work to children. Additionally, the work could be expanded to other types of morphologically complex words (e.g., derived word forms such as *nesher* or *neshist*). Work in Spanish has shown that skilled readers can generate orthographic skeletons of short monomorphemic disyllabic words (Jevtović et al., 2022). However, in English, polysyllables make spelling more difficult due to increases in length and complexity, and the introduction of potential difficulties arising from stress placement, and associated differences in the fullness of spoken vowels (e.g., the schwa in unstressed syllables). Future work should therefore address the issue of whether children will still be able to form orthographic skeletons of English monomorphemic polysyllabic words.

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Figure 1. Key terminology relevant to the association between oral vocabulary knowledge and word reading.

Term	Definition
Oral vocabulary	Refers to knowledge of word pronunciations (lexical phonology, or the sound patterns of words) *AND* word meanings (semantics).
Oral vocabulary breadth	Refers to the number of words whose pronunciations are recognized. Note: It is possible to know a word's pronunciation but not its meaning.
Oral vocabulary depth	Refers to the extent of knowledge about word meanings. Note: It is unlikely that a word's meaning is known without also knowing its pronunciation.
Print-to-pronunciation regularity	A binary distinction between regular and irregular words.
Regular words	When words contain the most common pronunciation for each grapheme they are regarded as regular for reading (e.g., *chop*, *bleak*)
Irregular words	Words containing one or more grapheme pronunciations that differ from the most common pronunciations are considered irregular for reading (e.g., *chef*, *break*).
Consistency	Refers to the degree to which the relationships between letters and sounds or between sounds and letters is predictable. It can be binary but is more often used continuously.
Print-to-pronunciation consistency	The degree to which a pronunciation can be predicted from a word's spelling.
Pronunciation-to-print consistency	The degree to which a spelling can be predicted from a word's pronunciation.

Figure 2. Research designs used to investigate the relationship between oral vocabulary and word reading, and the specific hypotheses they test.

Research design	Basic procedure	Hypothesis being tested
Cross-sectional studies of individual differences	Participants complete standardised measures of oral vocabulary (breadth and/or depth) and word reading (regular and/or irregular). Other reading-related skills are often tested (e.g., phonological awareness). By-participant correlations are computed.	Is there a general, person-level association between oral vocabulary knowledge and word reading? As a correlational design, it cannot provide evidence for causation. In this specific context, correlations might arise indirectly because a child is generally good, or poor, at learning. Alternatively, they might arise directly because oral vocabulary plays an active role in learning to read new words.
Cross-sectional item-level studies	Different measures are taken on the same set of real words chosen by the researcher. Participants' oral knowledge of the words is assessed (pronunciation knowledge is often assessed separately from meaning knowledge). Written word forms might be regular or irregular, and reading accuracy is tested via a reading aloud task. Other reading-related skills may be tested.	Is there a direct relationship between knowing a spoken word and the likelihood of reading it correctly? As a correlational design, it cannot establish causation. However, the existence of a direct relationship between spoken and written word knowledge justifies further investigation of the relationship.
Longitudinal studies	Participants typically complete standardised measures of oral vocabulary at time point one (depending on age, other measures of broader language and reading skills may also be taken). After a period of months or years of formal reading instruction, participants complete standardized measures of word reading (other measures of oral vocabulary or broader language skills may also be taken).	Are variations in oral vocabulary knowledge that exist prior to learning to read, or early in the process of learning to read, strong correlates of later variations in word reading? While correlational, these studies can indicate that a cause precedes a given effect. Therefore these studies suggest, but do not establish, that the relationship is causal.
Training studies	The spoken form of a set of novel words is taught (pronunciations with or without their meanings). Later, participants read the orally trained words in print for the first time, along with another set of novel words that are entirely unfamiliar (i.e., untrained).	Does training in oral vocabulary knowledge lead to improvements in later reading accuracy or efficiency? Training studies provide the most convincing evidence for causal relationships. They test the idea that training in a given skill produces improvement in a different skill.