What do we know about reading and spelling in shallow orthographies?

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Abstract: Reading and spelling research has traditionally been centred on English, despite its significant differences from other European orthographies. This anglocentric focus raises questions about the generalisability of reading theories to alphabetic orthographies. Understanding cross-linguistic differences in reading acquisition is crucial, given the practical implications for literacy instruction and dyslexia intervention. Shallow orthographies enable faster mastery of grapheme-phoneme correspondences, while deep orthographies may necessitate stronger reliance on alternative strategies such as lexical guessing and reliance on larger sublexical units. The cognitive mechanisms underlying fluency development, particularly the role of high-quality lexical representations, provide open research questions for further research. Spelling accuracy is also affected by orthographic depth, with greater challenges in deep orthographies due to ambiguous phoneme-grapheme mappings. While phonics instruction is well-established, research on enhancing lexical processing to support reading fluency and spelling acquisition is limited. This paper synthesises current cross-linguistic findings, highlights gaps, and discusses practical implications for literacy instruction across alphabetic orthographies.
Keywords: Orthographic learning; Orthographic Depth Hypothesis; reading aloud; spelling.

ᴱˢ ¿Qué sabemos de la lectura y deletreo en ortografias superficiales?

Resumen: La investigación sobre la lectura y la ortografía se ha centrado tradicionalmente en el inglés, a pesar de sus notables diferencias con otras ortografías europeas. Este enfoque anglocéntrico plantea dudas sobre la generalización de las teorías de la lectura a las ortografías alfabéticas. Comprender las diferencias interlingüísticas en la adquisición de la lectura es crucial, dadas las implicaciones prácticas para la alfabetización y la intervención en la dislexia. Las ortografías poco profundas, o superficilaes, permiten un dominio más rápido de las correspondencias grafema-fonema, mientras que las ortografías profundas pueden requerir una mayor dependencia de estrategias alternativas como la dependencia de unidades subléxicas más grandes. Los mecanismos cognitivos que subyacen al desarrollo de la fluidez lectora, en particular el papel de las representaciones léxicas de alta calidad, ofrecen cuestiones abiertas a futuras investigaciones. La precisión ortográfica también se ve afectada por la profundidad ortográfica, con mayores dificultades en las ortografías profundas debido a la ambigüedad de las correspondencias fonema-grafema. Mientras que la enseñanza de la fonología está bien establecida, la investigación sobre la mejora del procesamiento léxico para apoyar la fluidez lectora y la adquisición de la ortografía es limitada. Este artículo sintetiza los hallazgos lingüísticos actuales, destaca las lagunas y analiza las implicaciones prácticas para la enseñanza de la lectoescritura en ortografías alfabéticas.
Palabras clave: Aprendizaje ortográfico; Deletreo; Lectura en voz alta; Profundidad ortográfica.

Summary: What do we know about reading and spelling in shallow orthographies? What are the consequences of cross-linguistic differences for the cognition of reading? How can we support reading and spelling acquisition in shallow orthographies?. Conclusions and open questions. References.

What do we know about reading and spelling in shallow orthographies?

In language research, many results and models are based on investigations in English (Blasi et al., 2022; Huettig & Ferreira, 2022; Share, 2008a, 2021). In reading and spelling research, this is an important limitation: English differs from other European orthographies in several aspects. This raises the question about which results are generalisable to theories of reading research in alphabetic orthographies. This question is pertinent, as reading research has practical implications: theories of reading inform instructions at school, as well as diagnosis and treatment of developmental dyslexia (Castles et al., 2018).

Despite the overall criticism that reading research focusses on English, studies over the past decades have provided some insights into how reading differs in other European orthographies. On the linguistic level, English is an outlier among European orthographies because of its orthographic depth: Words are often not read in the way that they are spelled (Borgwaldt et al., 2005; Schmalz et al., 2015; van den Bosch et al., 1994). Two major theories explain cross-linguistic differences in alphabetic orthographies: the Orthographic Depth Hypothesis (Katz & Frost, 1992) and the Psycholinguistic Grain Size Theory (Ziegler & Goswami, 2005). The current article aims to summarise what we know about reading in non-English European orthographies, the remaining open questions, and the practical implications of applying existing models in practical settings across languages.

The focus of the current article is on single-word reading and spelling, reflecting the prevalence of this topic in the literature on reading research. Single words are the building blocks of the reading and writing process: The ultimate aim is to help children understand and write complex texts. To achieve this, however, children first need to read and spell single words accurately and fluently. Mastering the more basic processes related to single-word reading and spelling frees up mental capacity for higher-order processing (Graham et al., 1997; Pikulski & Chard, 2005). Therefore, to support young children in their literacy acquisition, we need to ensure that their single-word reading and spelling are both accurate and fluent.

What are the consequences of cross-linguistic differences for the cognition of reading?

An increasing number of studies on reading and spelling acquisition are conducted world-wide (e.g., Caravolas et al., 2012; Georgiou et al., 2012; Lei et al., 2011; Nag, 2007; Saiegh–Haddad, 2003; Seymour et al., 2003). Some studies specifically aim to understand how reading or spelling in English differs from reading in other European orthographies (e.g., Frith et al., 1998; Marinus et al., 2015; Mousikou et al., 2020; Viise et al., 2011). In these cross-linguistic studies, orthographic depth is the most-studied feature (e.g., Carioti et al., 2021; Ellis et al., 2004; Frost et al., 1987; Katz & Frost, 1992; van Daal & Wass, 2017). Orthographic depth describes the closeness of the relationship between print and speech (Schmalz et al., 2015): English is considered deep, because there are many words that are not pronounced the way that they are spelled, such as "Wednesday". In shallow orthographies, such as Spanish, most words are pronounced the same way that they are written. Orthographic depth can be described as a continuous and multidimensional space. Orthographies vary along a continuum in the extent to which the spelling is represented (Borgwaldt et al., 2005; Seymour et al., 2003). For example, the English orthography is considered to be deeper than the Portuguese orthography, but Spanish is more shallow than Portuguese (Serrano et al., 2011; Seymour et al., 2003). Orthographic depth is multidimensional, as the reasons for a lack of consistency between print and speech sounds vary (Schmalz et al., 2015; van den Bosch et al., 1994). For example, both in English and in Spanish, the letter 'g' has two possible pronunciations. In Spanish, however, a complex but predictable rule dictates the pronunciation of the letter 'g': it is pronounced as /x/ before the letters 'e' or 'i', as /g/ if it is not before the letters 'e' or 'i' and either at the beginning of a syllable or after 'n', and as /ɤ/ in all other contexts. In contrast, in English, the letter 'g' can have different pronunciations even in very similar contexts, such as in the words "gist" (/dʒ/) and "gift" (/g/). To know the pronunciation of the words "gist" and "gift" in English, one needs to know the pronunciation of the whole word, making the pronunciation unpredictable by letter-sound rules (Schmalz et al., 2015). To date, we know little about the differential effects of different dimensions underlying orthographic depth on reading processes (but see De Simone et al., 2021; Schmalz et al., 2022; Schroeder et al., 2021). Therefore, the following discussion does not draw a distinction between the different dimensions and refers to the overarching concept, that may encompass different facets.

Theories of cross-linguistic differences in reading

Orthographic depth is in the foreground of cross-linguistic reading research, to the extent that it has a central role in two of the most prominent theories of reading across languages, the Orthographic Depth Hypothesis (Katz & Frost, 1992) and the Psycholinguistic Grain Size Theory (Ziegler & Goswami, 2005). The effects of orthographic depth on reading processes were first described by the Orthographic Depth Hypothesis (Frost et al., 1987; Lukatela et al., 1980). The Orthographic Depth Hypothesis makes certain assumptions about the cognition of reading. Specifically, it relies on the Dual Route framework of reading (Coltheart et al., 2001; Paap & Noel, 1991; Perry et al., 2007; Perry et al., 2010). Dual Route theories propose that, to obtain the pronunciation of a written word, the reader uses two cognitive strategies, in parallel. The first cognitive strategy is sublexical processing, where each grapheme is converted to a phoneme and the set of phonemes is then synthesised into a spoken word form. The second strategy is lexical processing. This is a direct look-up procedure, where the written word is directly activated, based on known words in the mental orthographic lexicon, and mapped to a phonological word form in the phonological lexicon, which consists of the words that a child knows in their spoken form. In deep orthographies, accurate reading can only be achieved by relying on the lexical route: for words like "Wednesday", the sublexical route would return an incorrect, regularised form, such as "wed-ness-day". This led to the proposal that the sublexical route is relatively more important in shallow orthographies (Frost et al., 1987; Lukatela et al., 1980). Although it has since become clear that both the lexical and the sublexical route

play an important role in reading across all European orthographies, it does indeed seem to be the case that the lexical route is relatively more important when adults read in a deep orthography (Schmalz et al., 2016).

In the context of reading acquisition, sublexical processing also appears to have a stronger role during reading in shallow compared to deep orthographies (Schroeder et al., 2021). However, the development of the cognitive processes underlying reading acquisition process is interactive and dynamic. This is specified in the Self-Teaching Hypothesis (Share, 1995). This theory explains how children establish representations in their mental orthographic lexicon. A critical self-teaching mechanism is sublexical knowledge: if a child encounters a word that is unfamiliar in its written form, sublexical decoding will allow them to sound out this word and to map it onto a familiar spoken word form in the phonological lexicon. Repeated and correct decoding will then lead to a creation of a representation in the mental orthographic lexicon. While the Self-Teaching Hypothesis is not concerned with cross-linguistic differences directly, it can be combined with the Orthographic Depth Hypothesis to make predictions about the effects of orthographic depth on reading acquisition. Specifically, in shallow orthographies, it is generally easier to learn the grapheme-phoneme correspondences. As expected according to the Orthographic Depth Hypothesis, this allows for a stronger reliance on sublexical processing in shallow orthographies (Schroeder et al., 2021; Viise et al., 2011). At the same time, according to the Self-Teaching Hypothesis, the lexical route is acquired, to a large extent, by establishing orthographic representations via sublexically decoding them (Share, 1995). Thus, the facilitation of acquiring the sublexical knowledge in shallow orthographies also seems to be speed up the development of the lexical route (Carrillo et al., 2013).

The second prominent theory that focusses specifically on cross-linguistic differences and orthographic depth is the Psycholinguistic Grain Size Theory (Ziegler & Goswami, 2005). A strength of the Psycholinguistic Grain Size Theory, compared to the Orthographic Depth Hypothesis, is its focus on reading acquisition rather than on skilled adult reading. However, the Orthographic Depth Hypothesis has the strength of relying on a specific theoretical framework, which makes it easier to understand the cognitive mechanisms behind its claims and to make and test specific predictions. The Psycholinguistic Grain Size Theory suggests that learning to read involves learning the orthographic units that map onto phonology. In extremely shallow orthographies, such as Czech or Finnish, learning the letters and their pronunciations is almost sufficient to achieve high accuracy in reading aloud. Thus, very small units, or single letters, are important grain-sizes for learning to read in Czech and Finnish. In orthographies such as Spanish or German, some knowledge of multi-letter clusters is required to achieve high reading accuracy: for example, in Spanish, the letter cluster *ch* is pronounced as /tʃ/, and is thus more predictive of a word such as "lucha" than the single-letter correspondences. Relying on multi-letter clusters thus increases the transparency of the orthography-phonology mapping, but at the same time increases the number of units that the children need to learn. Furthermore, relying on small units poses a challenge for the cognitive system, because it requires the awareness of phonemes, or speech sounds, which typically map onto individual letters (Sodoro et al., 2002). This awareness tends to develop only after the onset of reading (Schmitterer & Schroeder, 2019), thus potentially pushing children towards reliance on larger units (Asfaha et al., 2009).

Despite the theoretical work on orthographic depth, open questions remain about the cognitive mechanisms that children use to compensate for the complexity or unpredictability of the grapheme-phoneme correspondences in deep orthographies. Studies have proposed strategies such as lexical guessing, where partial sublexical information is used to activate a word in the mental lexicon (Frith et al., 1998), reliance on sentence context (Schroeder et al., 2021), or reliance on larger sublexical units, such as body-rime correspondences (e.g., reading an English word like "stalk" by mapping the body *-alk* onto the rime /o:k/) (Ziegler et al., 2003). Although the Psycholinguistic Grain Size Theory proposes that reliance on larger units is a consequence of learning to read in a deep orthography, it is under-specified whether such larger units are lexical or sublexical. Furthermore, the evidence for differential reliance on larger sublexical units across orthographies is inconsistent (Schmalz et al., 2017).

The fluency challenge

Orthographic depth has consequences for aspects of reading beyond the ratio of lexical-to-sublexical processing. From a more down-to-earth perspective, an aspect that is relevant in educational settings is that children are able to read and spell accurately and fluently. In this regard, one of the most consistent findings in reading acquisition is that children learning to read in shallow orthographies learn to read accurately much sooner after the onset of schooling, compared to English-speaking children (Seymour et al., 2003). This means that orthographic depth has implications for the manifestation of reading problems: As achieving high accuracy is not the main bottleneck for European orthographies other than English, individual differences are observable in reading fluency (Landerl & Wimmer, 2008; Wimmer & Mayringer, 2002). Thus, it is important to understand what cognitive processes enable fast, fluent reading.

From the perspective of the Dual Route framework, reading speed increases once children establish orthographic representations that allow them to rely on the lexical route (Castles & Nation, 2010). In shallow orthographies, relying on the sublexical route will often yield a correct pronunciation. However, the letter-by-letter decoding process is slow and effortful, compared to direct lexical access. Children who struggle to read in shallow orthographies show slow orthographic learning (Suárez-Coalla et al., 2014). Furthermore, the lexical route allows for direct access, not only to the pronunciation, but also to the meaning of a word. Thus, it may be suggested that problems with reading fluency should be overcome by teaching children to rely on the lexical route (Thaler et al., 2004). Nevertheless, empirical evidence shows that, in practice, it is difficult to increase reading speed in children, even in programmes that aim to increase reliance on the lexical route. Specifically, it is difficult to improve reading ability beyond the set of words that are trained (Marinus et al., 2012; Thaler et al., 2004).

From a theoretical perspective, encouraging reliance on lexical processing may involve strengthening high-quality lexical representations (Perfetti & Hart, 2002). In the Lexical Quality Hypothesis, high-quality lexical representations are defined as word-specific knowledge which contains detailed information about the orthographic word form (i.e., the letters of the word in the correct order) and strong connections between this orthographic word form and the phonological and semantic information that it corresponds to (Perfetti & Hart, 2002). In the context of reading fluency, relying on a lexical representation requires that the representation is sufficiently detailed that exposure to a word will trigger the activation of phonology and semantics. At the same time, achieving high reading speed also requires that lexical access happens quickly (Bakos et al., 2018). Quality (which enables accurate reading) and speed of access (which is necessary for fast reading) might therefore be partially independent (Jabbour-Danial et al., 2024; Shany et al., 2023; Shany & Share, 2011).

Other approaches to increasing reading fluency have focussed on training reliance on sublexical units that involve multi-letter clusters (Heikkilä et al., 2013; Huemer et al., 2008; Marinus et al., 2012). Theoretically, if children learn to parse words into orthographic units than are larger than letters, there will be fewer clusters for them to process, which may speed up reading (Wimmer, 2006). In many studies, the results parallel those of the lexical training studies: while children improve at reading the letter clusters that have been trained, there is little evidence of transfer to reading in a real-life setting. The greatest benefits may stem from training uncommon and long letter clusters, such as low-frequency syllables (Heikkilä et al., 2013).

Open questions remain about the utility of training different types of clusters: for example, some larger units may provide a more direct link to the meaning of a word. Specifically, morphemes are the smallest units of meaning, such as the units *dis-*, *establish*, and *-ment* in the word "disestablishment". Experimental studies have shown that morphology plays an important role in word recognition (Häikiö & Vainio, 2018; Lázaro et al., 2015; Lázaro & Calvo Expósito, 2013). In contrast to training reliance on sublexical units such as syllables, teaching children to focus on morphology may help them not only to increase their reading speed, but also provides a more direct link to the meaning of a word.

Single-word spelling in shallow orthographies

To date, most of the research on orthographic depth has focussed on reading. The studies on single-word spelling suggest that, just as in reading, accuracy is lower in children learning to read and write in English than other European orthographies (Caravolas, 2004). Orthographic depth can be considered in the orthography-to-phonology direction, as is often done in the research on reading: If we have a written word, can we derive one correct pronunciation based on the orthography? For spelling, the phonology-to-orthography direction is more important: If we want to spell a word, can we create a string of graphemes that uniquely corresponds to the phonemes? English is deep both in both directions (e.g., out of context, the word "wind" can be pronounced as /wɪnd/ or as /wɑɪnd/, and the word /bræɪk/ can be spelled as "break" or as "brake"). Most, or maybe even all, orthographies are shallower in the orthography-to-phonology (reading) than in the phonology-to-orthography (spelling) direction, which poses a challenge for accurate spelling. Even shallow orthographies, such as Spanish, contain phonemes that can be spelled in multiple ways, such as /β/ having both *v* and *b* as plausible spellings. To spell a word with an ambiguous spelling correctly, the learner has to establish a detailed, high-quality lexical representation of this word (Mehlhase et al., 2019). Additionally, knowledge of spelling rules or clusters larger than graphemes may facilitate spelling (Treiman & Kessler, 2022). Such knowledge could involve awareness of graphotactic constraints, such as knowing that letter clusters such as *ck* in English cannot occur at the beginning of a word, or morphological regularities, such as knowing that nouns ending in /ʃən/ in English are likely to be spelled with the morpheme *-tion*.

How can we support reading and spelling acquisition in shallow orthographies?

A majority of published training studies have focussed on improving reading and spelling outcomes in English-speaking children (Galuschka et al., 2014). This means that there is a relative scarcity of empirical results from shallow orthographies. Nevertheless, we have sufficient evidence to provide some recommendations, both by generalising results from English and by relying on the available evidence from other languages.

A general recommendation is to improve reading and spelling ability to training skills that are directly related to cognitive processes involved in reading and spelling, for example, by using print-related training material rather than improving distantly related cognitive skills such as visual attention (Galuschka et al., 2020; Huemer et al., 2018; McArthur & Castles, 2017; Schulte-Körne & Bruder, 2010). This is supported by meta-analyses, which show that the most effective instruction and remediation methods focus on aspects of the orthography or phonology (Galuschka et al., 2020; Galuschka et al., 2014). From a theoretical perspective, cognitive processes that are part of the reading system are proximally related to reading ability: thus, improving such processes should have a more immediate benefit than training distal causes (Coltheart, 2015). Examples of cognitive process which are distally related to reading and spelling are domain-general cognitive skills, visual processes (Franceschini et al., 2017; Valdois et al., 2003) or statistical learning (Gabay et al., 2015). Often, the evidence for any type of link between such distal causes and reading ability or dyslexia is contentious (Banfi et al., 2018; Perry & Long, 2022; Schmalz et al., 2019; van Witteloostuijn et al., 2019). If we assume that a correlation between a distal skill and reading or spelling ability exists, the mechanisms likely involve a causal chain with multiple links. For example, visual processing may facilitate children in identifying more letters simultaneous, leading to faster lexical processing and subsequently better reading abilities. However, none of the links are deterministic: at each node in the causal chain, multiple factors affect the subsequent link. This should reduce the size of the correlation between distal causes and the end outcome of good reading and spelling (Schmalz

et al., 2021). In educational practice, one is therefore likely to achieve larger effects by focussing on cognitive skills that are more proximally related to reading and spelling ability.

Many studies on improving reading and spelling skills have focussed on teaching grapheme-phoneme correspondences (Galuschka et al., 2020; Galuschka et al., 2014). In shallow orthographies, learning the grapheme-phoneme or phoneme-grapheme correspondences is a relatively fast process (Acha et al., 2023), and even struggling readers generally achieve high accuracy relatively quickly after the onset of reading instructions (Landerl & Wimmer, 2008; Seymour et al., 2003; Tressoldi et al., 2001). Ensuring that children know the letters and grapheme-phoneme correspondences is still an important step, especially for very young readers (Georgiou et al., 2012). As proposed by the Self-Teaching Hypothesis, the knowledge of grapheme-phoneme correspondences provides a powerful mechanism for reading novel words: as such, a lack thereof can have a cascading effect on all subsequent phases of reading acquisition. One of few reading instruction methods that has been tested across multiple languages is a computer-based serious game called "GraphoGame", which systematically trains grapheme-phoneme correspondences (https://graphogame.com/). GraphoGame has been tested in shallow orthographies as well as in English, with some studies indicating its success (Kyle et al., 2013; Lovio et al., 2012; Saine et al., 2010). However, not all studies showed a benefit, and a meta-analysis found that the associated effect sizes may be small (McTigue et al., 2020). While several UK-based researchers have argued for the importance of phonics instructions worldwide (Crawford et al., 2025; Goswami, 2005), its global importance may be overstated due to the literature's bias on English.

From a theoretical perspective, grapheme-phoneme knowledge is not sufficient for becoming a good reader and speller, because automatic word recognition and rapid retrieval of lexical representations are also important aspects of reading and spelling. Becoming fluent readers and sound spellers requires efficient reliance on the lexical route (Castles & Nation, 2010; Wimmer, 2006). When it comes to the question of how to best support lexical processing in an educational context, the evidence is mixed. Maximising reading experience should be an efficient way to create lexical knowledge, theoretically: this exposes children to words in context, so they can learn the orthographic word form and create strong links to the phonology of the word (Share, 2008b).

The importance of reading experience is also stressed by the Lexical Legacy Hypothesis (Nation, 2017). This hypothesis explains not only how the link between orthographic and phonological word forms is created, but also how we infer the meaning of unfamiliar words. According to the Lexical Legacy Hypothesis, children encounter words in different contexts when they read. This allows them to develop a rich representation of the word's meaning (Nation, 2017). Thus, maximising reading exposure is an important recommendation, both from the perspective of enriching the orthographic lexicon and increasing vocabulary size. Aside from the recommendation to read more, however, little research exists on targeted interventions that would specifically assess how to best improve the quality of or access to an orthographic representation (Colenbrander et al., 2020).

How to improve reliance on lexical processing is an open question with not only practical but also theoretical implications: If a specific word-training procedure improves certain aspects of reading or spelling ability, this would provide more detailed knowledge into the structure of a lexical representation. In contrast, relatively many studies have focussed on how to best teach grapheme-phoneme correspondences, such as in the context of phonics instructions (Ehri, 2022). This is likely to be a consequence of the anglocentricity of reading research, where knowledge of grapheme-phoneme correspondences is the first challenge associated with learning to read in English (Share, 2008a).

Predictors of reading and spelling overlap, as has been shown in deep and in shallow orthographies (Georgiou et al., 2012; Sigmund et al., 2024). Reading and spelling ability also mutually support each other (Frith, 1986). Thus, improving reading skills is likely to have a positive effect on spelling skills, and vice versa. Just as is the case for reading, for reading, ensuring solid letter knowledge and knowledge of phoneme-grapheme correspondences are important, especially at the beginning stages of literacy acquisition (Caravolas, 2004). The ability to learn such correspondences seems to be a strong predictor of later spelling ability (Mehlhase et al., 2025).

To further support spelling acquisition, studies, especially in shallow orthographies, have taught children about spelling patterns, such as morphemes (Arnbak & Elbro, 2000) or common orthographic patterns (Ise & Schulte-Körne, 2010). A meta-analysis has shown that, overall, orthographic training schemes are effective at improving spelling ability (Galuschka et al., 2020). In some orthographies, awareness of morphological patterns may improve spelling ability by resolving some ambiguity associated with phoneme-grapheme correspondences (Görgen et al., 2021): for example, in English, knowing that the word *magician* is related to the word *magic* will help the children to remember that it is not spelled *magishun*, even though this would be a phonologically plausible spelling. However, in orthographies which are shallower in the speech-to-spelling directions, such as Spanish, the role of morphology may be reduced (Lehtonen & Bryant, 2005). While morphology has important place in reading acquisition in shallow orthographies, including Spanish (Lázaro et al., 2015; López-Villaseñor & Calvo Expósito, 2013), there may not be a large additional value in teaching morphology or other common spelling patterns to increase spelling accuracy, specifically.

Conclusions and open questions

Single-word reading and spelling skills form the basis of literacy acquisition, which are, in turn, an important building block of education across fields of study. What we know about reading and spelling, and how to support children who struggle with these skills, is based to a large extent on the English language (Huettig & Ferreira, 2022; Share, 2021). Both in research and in educational practice, this is likely to result in an imbalance, where aspects of reading and spelling acquisitions are emphasised that may be less important in shallow orthographies compared to English. Many theories have been proposed based on empirical findings from English, and only two specifically address how reading processes should differ in orthographies that are less deep than

English. Table 1 summarises relevant cross-linguistic and single-language theories, as well as their practical implications and open questions for educational practices in the context of shallow orthographies.

Table 1. Theories described in the current article, and their practical implementations

Theory	Brief description	Practical implications	Open questions
Dual-Route Framework (Coltheart et al., 2001)	Deriving a pronunciation from a written word form can occur via sublexical processing (relying on letter-sound correspondences) or lexical processing (activating the pronunciation and meaning of a known word directly).	Sublexical reading (letter-sound knowledge) is a necessary skill that allows children to read unfamiliar words. Lexical reading allows children to get from a written word to its pronunciation and meaning more quickly.	Although there are established training programmes of letter-sound knowledge, we don't know how to increase reliance on lexical processing, beyond training specific words.
Orthographic Depth Hypothesis (Katz & Frost, 1992)	In shallow orthographies, the ratio of sublexical-to-lexical processing is higher than in deep orthographies.	Both lexical and sublexical processes are important, despite cross-linguistic differences in their relative usage.	How do the developmental trajectories differ across languages for lexical and sublexical processing? Should we differentially train one or the other process in shallow orthographies?
Psycholinguistic Grain Size Theory (Ziegler & Goswami, 2005)	In shallow orthographies, readers can rely on small units, such as letter-phoneme correspondences and a few multi-letter graphemes, provided they have sufficient phonological awareness.	Letter-sound knowledge and phonological awareness may be especially important in shallow orthographies.	How can we describe the psychological mechanisms behind reliance on different units? Can and should we specifically train reliance on different types of units?
Self-Teaching Hypothesis (Share, 1998)	Sublexical processing is essential for establishing orthographic representations, which is the process by which the mental orthographic lexicon is filled.	Letter-sound knowledge is required to enable children to learn whole words. Reading exposure is important to provide children with opportunities to fill their orthographic lexicon.	What are the implications for the developmental trajectories of lexical and sublexical processing in orthographies differing in orthographic depth?
Lexical Quality Hypothesis (Perfetti & Hart, 2002)	Fluent and accurate reading requires lexical representations that are of high quality, in the sense that they can be activated quickly and have strong links between orthography, phonology, and semantics.	To maximise reading fluency and comprehension, children need to learn about all three aspects of a word: i.e., its orthography, phonology, and semantics. Reading exposure can help to strengthen words' lexical quality.	Are there any targeted interventions that can help improve lexical quality?
Lexical Legacy Hypothesis (Nation, 2017)	Learning about a word's meaning, in addition to its pronunciation, requires seeing the word frequently and in different contexts.	In addition to maximising reading exposure, one should also pay attention to the diversity of the topics covered by the reading materials.	How to improve lexical legacy for children who are extremely unmotivated to read?

In English, knowledge of grapheme-phoneme and phoneme-grapheme correspondences is critical to allow children to start reading and spelling words. This knowledge then needs to be supplemented by knowledge of whole words, in the form of high-quality lexical representations. Knowledge about common spelling patterns, including morphemes, may further facilitate spelling ability. This general progression of the importance of skills is likely to be generalisable across languages, although systematic cross-linguistic empirical evidence is scarce (Ehri, 1995; Verhoeven & Perfetti, 2022; Wimmer, 2006).

Cross-linguistic studies have yielded important insights about supporting literacy acquisition in languages other than English. Specifically, many non-European orthographies are shallower than English. This decreases the relative importance of training grapheme-phoneme and phoneme-grapheme correspondences: while these are still essential for acquiring solid reading and spelling skills, they are more easily learnt in shallow orthographies. Once solid knowledge of grapheme-phoneme and phoneme-grapheme correspondences is established, other cognitive processes may be more important to target in order to improve reading and spelling. Here, open questions remain.

From a theoretical perspective, improving lexical processing should result in benefits both for reading and spelling. We also know that children with developmental dyslexia struggle with relying on the lexical route, including in shallow orthographies (Suárez-Coalla et al., 2014). However, we know relatively little about how reliance on lexical processing can be increased. Increasing reading exposure should boost reading and spelling ability, as it allows children to establish orthographic representations, including rich semantic knowledge of individual words (Nation, 2017). However, no specific training programmes exist which could be employed to support the learning of lexical representations, in those situations when children are not motivated to read. On this front, additional research is needed to compare the effectiveness of existing training programmes which aim to increase reading speed across languages (Bowers et al., 2010; Heikkilä et al., 2013).

In shallow orthographies, learning about common letter patterns has been shown to improve spelling ability, including in children with developmental dyslexia (Galuschka et al., 2020). This includes teaching children about morphology. Open questions remain about the effectiveness of such programmes cross-linguistically. Furthermore, improving reliance on lexical processing should theoretically improve spelling ability. However, to date, training schemes struggle to improve lexical knowledge beyond the set of words that are explicitly trained in the given programme.

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