LSHSS

Review Article

To See or Not to See: How Does Seeing Spellings Support Vocabulary Learning?

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Purpose: The aim of this study was to determine when, why, and how the presence of a word's written form during instruction aids vocabulary learning (a process known as *orthographic facilitation*).
Method: A systematic review of the research on orthographic facilitation was carried out. PsycInfo, Web of Science, ProQuest, and OpenGrey databases were searched. The search returned 3,529 results, and 23 of these met inclusion criteria. Studies were included in the review if they were written in English, published in a peer-reviewed journal, and compared vocabulary learning outcomes when words were taught with and without their written forms.
Conclusions: There is strong evidence that the presence of a word's written form leads to improved learning of its spelling and spoken form. There is also some evidence that it may lead to better learning of a word's meaning. A small number of studies have also shown that the presence of a word's written form benefits vocabulary learning in children with developmental language disorder, autism, Down syndrome, and reading difficulties. However, further research into the effects of orthographic facilitation in special populations is needed. In particular, ecologically valid experiments in clinical and educational settings are required in order to better understand how exposure to a word's written form can aid naturalistic vocabulary learning.

Vocabulary knowledge is fundamental to successful communication and academic achievement. Children and adults with high levels of vocabulary knowledge tend to be better at reading words and texts accurately and understanding what they read. Conversely, low levels of vocabulary knowledge are associated with poor reading and educational outcomes (Biemiller, 2003; Nation & Snowling, 2004; Ouellette, 2006; Perfetti, 2007; Ricketts, Nation, & Bishop, 2007; Suggate, Schaughency, McAnally, & Reese, 2018). Gaps in vocabulary knowledge between individuals appear early in development and tend to persist or even increase over time (Duff, Tomblin, & Catts, 2015; Hart & Risley, 1995; Stanovich, 1986). Thus, it is crucial to determine the best ways of teaching vocabulary in order to reduce such gaps.

Early in language development, children learn to associate spoken (phonological) forms of words with their meanings (semantics). Later, when children learn to read, they map these spoken forms and meanings onto written (orthographic) forms. The lexical quality hypothesis (Perfetti & Hart, 2001, 2002) states that high-quality lexical representations are necessary for efficient access to higher order meaning from spoken and written language. A word's representation in memory can be considered high quality when all three key elements of word knowledge (orthography, phonology, and semantics) can be retrieved in a coordinated manner. In practice, this means that, when a word is read, its orthographic form readily brings to mind its phonological form and meaning and, when it is heard, the phonological form activates orthography and meaning. In addition, meaning generates phonology and orthography so that a word can be pronounced or written down.

In literate individuals, vocabulary knowledge is closely associated with reading abilities. Deep and rich vocabulary knowledge underpins successful reading comprehension. Knowledge of words' spoken forms and meanings can also help children to read words. If a child encounters a regularly spelled word such as "handstand" and knows the usual mappings between those letters and sounds, then this word

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can be read correctly by decoding the letters into sounds, after which meaning can be accessed. Knowledge of spoken forms and meanings may supplement partial decoding attempts (Share, 1995) for poor readers or readers who do not know all of the letter–sound mappings in "handstand," and for words that include spelling patterns with unusual pronunciations such as "island" and "yacht." In these circumstances, less-able readers, or those encountering inconsistently spelled words for the first time, can partially decode the word (sound out the letters they know). This will result in a partial phonological form that may be similar to a spoken word that they already know, which in turn can help them arrive at a correct reading attempt (Dyson, Best, Solity, & Hulme, 2017; Tunmer & Chapman, 2012).

Conversely, written vocabulary knowledge appears to make it easier to process and learn spoken vocabulary items. A growing number of studies demonstrate that, when children and adults are shown the written (orthographic) forms of words during vocabulary instruction, they are better able to remember phonological and semantic information than when words are taught without their orthographic forms (e.g., Ricketts, Bishop, & Nation, 2009; Rosenthal & Ehri, 2008). This effect is known as *orthographic facilitation*.

There are a number of reasons why the presence of a word's written form may aid learning. Unlike phonological inputs, orthographic inputs are not transient over time: Written words stay on the page and may therefore be easier to remember. In addition, the end of a letter or a word is more clearly marked on the page than in the continuous speech stream. Furthermore, written words may be more consistent across contexts than spoken words due to variations in accents. Orthographic forms may therefore help to specify and clarify the nature of phonological forms and act as a mnemonic or anchoring device to help learners retain phonological forms in memory (Ehri, 2014; Ricketts et al., 2009; Rosenthal & Ehri, 2008).

This could occur due to "offline" processes whereby learning to read changes the way that individuals subsequently learn, store, and retrieve phonological forms (e.g., Frith, 1998). It may also occur "online" during the process of learning or retrieval. Orthographic information may be automatically activated when the phonological form of a word is processed, helping to specify the word's phonological form and leading to a stronger representation in memory (e.g., Ziegler, Muneaux, & Grainger, 2003). Both online and offline processes may operate, and in alphabetic languages, these processes are likely to be driven by the fact that links between orthographic and phonological information tend to be systematic and predictable (Ehri, 2014; Ricketts et al., 2009; Rosenthal & Ehri, 2008). If the presence of orthography supports phonological learning, learners may also find it easier to map phonological forms onto meaning. In this way, the presence of orthography may benefit learning for new phonological forms, new meanings, and the mappings between these.

While many studies have found evidence of orthographic facilitation, the effect has not always been observed consistently, which may reflect methodological differences across studies. Studies have adopted a variety of different vocabulary training methods, teaching simple associations between orthographic or phonological forms and semantic information (usually pictures), or richer definitions. Different studies have made use of a variety of measures of learning, and the types of words trained have also differed across studies, with participants trained on real words or nonwords, with consistent or inconsistent spelling patterns. It is of practical interest to know whether some types of words benefit from orthographic facilitation more than others, but this also has a bearing on theory. As discussed above, orthographic facilitation may occur because learners take advantage of systematic mappings between orthography and phonology. If this is the case, then we might expect orthographic facilitation to be more beneficial for words with consistent spellings (Jubenville, Sénéchal, & Malette, 2014). We might also predict greater orthographic facilitation in more "transparent" alphabetic languages such as Finnish and Italian, where mappings between orthography and phonology are very consistent, compared to more "opaque" languages such as English.

Studies have also investigated orthographic facilitation in different participant groups. In addition to typically developing children and adults, studies have included children with developmental language disorder (DLD) and other disorders such as dyslexia, autism spectrum disorder (ASD), and Down syndrome (Lucas & Norbury, 2014; Mengoni, Nash, & Hulme, 2013; Ricketts, Dockrell, Patel, Charman, & Lindsay, 2015). All of these disorders are associated, to some extent, with poor spoken vocabulary knowledge and poor reading (i.e., weak knowledge of relationships between orthography and phonology). It is important that we know whether these children will also benefit from seeing spellings when learning new spoken words.

The methods and results of orthographic facilitation studies have never been systematically cross-examined. This makes it difficult to provide clear recommendations for educational or clinical practice. Therefore, we conducted a systematic review of these studies to investigate the conditions under which exposure to orthographic forms of words fosters vocabulary learning, with the goal of understanding how findings from experimental studies can be utilized in practice. Our questions are as follows:

1. Does the presence of a word's written form aid learning of the phonological, orthographic, and semantic forms of unfamiliar words?
2. Who benefits from orthographic facilitation? Do children with developmental disorders (dyslexia, DLD, ASD, Down syndrome) and second language learners benefit as well as typically developing children?
3. When does orthographic facilitation occur? Does exposure to orthography need to be explicit, or is incidental exposure sufficient? Do words with consistent spellings benefit more than those with inconsistent spellings? Does the type of training procedure make a difference?

4. What is the mechanism driving orthographic facilitation?

Method

Search Strategy

We searched PsycInfo, Web of Science, ProQuest, and OpenGrey using the following search terms:

- Orthographic facilitation AND (vocabulary OR word) AND (learning OR instruction) AND reading
- Orthographic facilitation AND (vocabulary OR word) AND (learning OR instruction)
- Orthographic facilitation AND (vocabulary OR word)
- Orthographic facilitation AND (learning OR instruction)
- Orthographic facilitation

We searched Google Scholar using the above search terms, and this returned over 27,000 results. Upon inspection, a large proportion of these results were irrelevant. We therefore carried out another Google Scholar search with all of the above searches in parentheses. This search returned a total of 3,529 articles. Any duplicate results were removed, as were any results with titles and abstracts in a language other than English. This process resulted in a total of 781 studies. The second author and another independent rater then read the titles and abstracts of these 781 studies to determine whether or not they met the selection criteria. If there was a discrepancy, the first author made the final decision about whether or not to include a study. Studies were included in the review if

1. participants were required to learn new words;
2. there was a comparison between a condition in which the phonological and/or semantic forms of words were learnt with their orthographic forms and a condition in which they were learnt with no orthography (orthography-present vs. orthography-absent conditions);
3. the study was written, but not necessarily conducted, in English; and/or
4. the study appeared in a peer-reviewed journal.

In total, 17 of these 781 articles met criteria for inclusion in the review, with 21 studies across these 17 articles. The authors then examined the reference lists of the selected articles and identified two further articles that met the selection criteria. Thus, a total of 23 studies from 19 articles were included in the final review. The articles were divided among the three authors, who read the articles and coded them according to the criteria described below. Six of the articles were independently double-coded by two of the authors as a check on interrater reliability. No disagreements were identified.

Coding

Studies were coded according to the following criteria:

- Participant characteristics (number of participants, age, native language, any other relevant characteristics; see Table 1)
- Item characteristics (number of items, whether items were words or nonwords, whether spelling–sound consistency was manipulated; see Table 2)
- Training procedures (see Table 3)
  - How training was conducted (how much training was received, whether it was delivered one-on-one or in groups)
  - Whether the presence of orthography was incidental (no attention was drawn to it) or explicit (participants were told to pay attention to the written form of the word)
  - The type of semantic information that was learnt
  - Whether there was a visual control condition (i.e., Was semantic or phonological information presented with an additional visual cue in the orthography-absent condition to control for the number of sources of information?)
- Findings (see Table 4)
  - The learning assessments used
  - Whether orthographic facilitation was observed on all outcome measures
  - Whether the effects of orthographic facilitation were greater for better readers

Note that studies used a wide range of different methodologies, and there were insufficient numbers of similar studies to justify statistical meta-analysis.

Results

Does the Presence of a Word's Written Form Aid Learning of Phonological, Orthographic, and Semantic Information?

The 23 reviewed studies measured how well orthographic, phonological, and semantic information was learned. Three studies were conducted with adult populations (Han & Choi, 2016; Miles et al., 2016; Saletta, Goffman, & Brentari, 2016), and one was conducted with both child and adult populations (Saletta, Goffman, & Hogan, 2016), whereas the remaining studies were conducted with child populations. We categorized outcome measures as "phonological" if participants were required to learn phonological information, produce phonological responses, or select between phonological stimuli. Similarly, "orthographic" outcome measures were those that involved learning orthography, producing orthographic responses,

Table 1. Participant characteristics.

Authors	*N*	Population	Mean age/age range (years)	Language
Baron et al. (2018)	92	46 TD children and 46 DYS with average OL	7–8	English
Chambré et al. (2017)	45	Grade 1 TD children	6.70	English
Ehri & Wilce (1979), Study 1	48	Grade 1 and 2 TD children	Grade 1: 6.43, Grade 2: 7.78	English
Ehri & Wilce (1979), Study 2	30	TD children	6.90	English
Ehri & Wilce (1979), Study 3	24	TD children	7.80	English
Han & Choi (2016)	48	TD adults	19–29	Korean
Hu (2008)	74	37 Children with stronger PA and 37 with weaker PA	8;10 (years;months)	Chinese-speaking ELL
Jubenville et al. (2014), Study 1	71	TD children	9.17	French
Jubenville et al. (2014), Study 2	64	TD children	9.25	Bilingual French–English
Li et al. (2016)	24	TD children	8.04	Mandarin Chinese
Lucas & Norbury (2014)	41	21 TD children, 20 children with ASD	9–12	English
Mengoni et al. (2013)	44	17 DS and 27 TD children matched on word reading	DS: 7–16, TD: 5–7	English
Miles et al. (2016)	25	12 MO and 14 ELL adults	MO: 24.09, ELL: 24.33	English MO and ELL
Reitsma (1983), Study 1	16	TD children	8.30	Dutch
Ricketts et al. (2009)	58	TD children	8–9	English
Ricketts et al. (2015)	81	27 DLD children, 27 ASD, 27 TD	8–13	English
Rosenthal & Ehri (2008), Study 1	20	TD children	7.58	English
Rosenthal & Ehri (2008), Study 2	32	TD children	10.92	English
Saletta, Goffman, & Brentari (2016)	18	TD adults	19–64	English
Saletta, Goffman, & Hogan (2016)	52	15 TD adults, 18 adult PR, 17 TD children	Adults: 19–64, children: 6–9	English
Savaiano et al. (2015)	3	VI children	9–12	English
Vadasy & Sanders (2015)	69	ELL children	6.15	English
Valentini et al. (2018)	71	TD children	9.03	English

Note. TD = typically developing; DYS = children with dyslexia; OL = oral language; PA = phonological awareness; ELL = English language learners; ASD = autism spectrum disorder; DS = Down syndrome; MO = monolingual; DLD = developmental language disorder; PR = poor readers; VI = visually impaired.

or choosing between orthographic stimuli, and "semantic" measures were those that required learning, recall of, production of, or selection between semantic stimuli (i.e., pictures, definitions). For example, picture naming was categorized as a phonological task because it requires participants to produce a phonological label for a stimulus, whereas word–picture matching was categorized as a semantic task because it requires participants to select from different semantic referents (though both tasks require knowledge of the mappings between semantic and phonological information).

Of the 23 studies, 11 contained measures of orthographic, phonological, and semantic learning; three contained measures of semantic and phonological learning (Baron et al., 2018; Hu, 2008; Li et al., 2016); two contained measures of semantic and orthographic learning (Savaiano et al., 2015; Vadasy & Sanders, 2015); and one measured semantic learning only (Reitsma, 1983). The remaining six studies contained measures of only phonological learning. Every study showed evidence of orthographic facilitation on at least one of the outcome measures. Notably, though, findings for orthographic and phonological learning were more consistent than findings for semantic learning.

Orthographic Learning

Orthographic learning relates to how well new orthographic forms are learned. Logically, it is reasonable to expect orthographic learning to be better when children have been exposed to orthography than when they have not. Indeed, this outcome acts as a manipulation check for orthographic facilitation experiments: If orthographic learning is higher for orthography-present than orthography-absent conditions, this verifies that children were sensitive to the presence of orthographic forms.

Thirteen studies included measures of orthographic learning. Spelling to dictation was the most common measure of orthographic learning, though two studies used orthographic choice tasks. Twelve of the 13 studies found evidence of an orthographic facilitation effect for learning the written forms of words (see Table 4). The remaining study did not statistically compare the accuracy of orthography-present over orthography-absent conditions (Han & Choi, 2016), so it is unclear whether there was an orthographic facilitation effect or not. Overall, there is robust evidence that the presence of orthography during learning leads to superior spelling performance for typically developing children and adults.

Table 2. Item characteristics.

Authors	Word type	Characteristics	Words learnt	Spelling consistency manipulated?
Baron et al. (2018)	Nonwords	Bisyllabic CVCCVC	4	No
Chambré et al. (2017)	Words	Monosyllabic	12	No
Ehri & Wilce (1979), Study 1	Nonwords	Monosyllabic CVC	16	No
Ehri & Wilce (1979), Study 2	Nonwords	Monosyllabic CVC	12	No
Ehri & Wilce (1979), Study 3	Nonwords	Monosyllabic CVC	16	No
Han & Choi (2016)	Nonwords	Multisyllabic	10	No
Hu (2008)	Pseudonames	Monosyllabic CVC, CVCC, and CCVCC	3	No
Jubenville et al. (2014), Study 1	Nonwords	Multisyllabic	12	Yes
Jubenville et al. (2014), Study 2	Nonwords	Multisyllabic	12	Yes
Li et al. (2016)	Pseudocharacters	Phonologically and semantically accurate or misleading characters	12	Yes
Lucas & Norbury (2014)	Words	Multisyllabic low-frequency science words	16	No
Mengoni et al. (2013)	Nonwords	Monosyllabic CVC	10	No
Miles et al. (2016)	Words	Multisyllabic low frequency	20	No
Reitsma (1983), Study 1	Nonwords	Regular	6	No
Ricketts et al. (2009)	Nonwords	Monosyllabic	12	Yes
Ricketts et al. (2015)	Nonwords	Monosyllabic	12	No[a]
Rosenthal & Ehri (2008), Study 1	Words	Monosyllabic low-frequency CVC	12	No
Rosenthal & Ehri (2008), Study 2	Words	Multisyllabic low-frequency concrete nouns	20	No
Saletta, Goffman, & Brentari (2016)	Nonword names	Disyllabic CVCCVC	6	Yes
Saletta, Goffman, & Hogan (2016)	Nonword names	Disyllabic CVCCVC	6	Yes
Savaiano et al. (2015)	Words	Different set for each participant, matched for lexical characteristics	18	No
Vadasy & Sanders (2015)	Words	Difficult irregular words	16	No
Valentini et al. (2018)	Words	Low frequency	8	No

Note. C = consonant; V = vowel.

[a]Items varied in consistency, but consistency conditions were not analyzed separately due to small numbers of items.

Phonological Learning

While it seems obvious that we should see orthographic facilitation for orthographic learning, more interesting is whether the presence of orthography consistently facilitates phonological learning (i.e., how well new phonological forms are learned). Nineteen studies included measures of phonological learning that required the production of phonological forms, such as picture naming, number of trials taken to learn the correct pronunciation, or number of sounds correctly recalled. One further study (Valentini et al., 2018) used a forced-choice task in which children were asked to choose between two alternative pronunciations for the target words. All studies except that of Valentini et al. (2018) found evidence of an orthographic facilitation effect on phonological learning (see Table 4).

It is worth noting that the design of Valentini et al. (2018) was atypical for this set of studies. Children learned new words from story context, in either listening, reading, or combined listening and reading conditions. This meant that, in the orthography-present condition, children were exposed to many orthographic forms, rather than just the orthographic forms for the to-be-learned items. Different findings for Valentini et al. may also be explained by their measure of phonological learning. As the authors noted, their two-alternative forced-choice task may not have been as sensitive to differences in phonological knowledge as a task requiring production of the phonological form. They also acknowledged that the task might tap other skills such as general sensitivity to wordlikeness (correct alternatives may have been more wordlike than foils).

Thus, a question remains about whether the presence of orthography benefits phonological learning of unfamiliar words in story contexts and whether it benefits perception and production for phonological learning. Nonetheless, there is strong evidence that providing children and adults with the written forms of words during vocabulary training helps them to remember phonological information.

Semantic Learning

Semantic learning relates to learning the meanings of words and learning mappings between meanings and either the phonological or orthographic form of a word, or both. Given that the presence of orthography facilitates learning of orthographic and phonological forms, it is possible that this benefit will have knock-on effects for learning semantics. Sixteen studies included at least one measure of semantic learning, utilizing tasks such as word–picture matching, semantic categorization, verbal definition, and multiple-choice definition recognition tasks. Four studies could not calculate statistical comparisons because scores on their measures of semantic learning were at ceiling (Han & Choi, 2016; Jubenville et al., 2014; Miles et al., 2016). Of the remaining 11 studies, eight found significant orthographic facilitation effects on at least one measure (Baron et al., 2018; Li et al., 2016; Lucas & Norbury,

Table 3. Training procedures.

Authors	Delivery method	Semantic information learnt	Orthography: incidental or explicit	Visual control condition	Procedure
Baron et al. (2018)	One to one	Pictures of monsters	Incidental	No	Learning and assessment phases were alternated across four blocks. In learning phases, children heard, or heard and saw the name of an object and touched a screen to select the correct monster. They received feedback as to accuracy. In assessment phases, children completed a naming task. In Block 1, there were two trials per word, and in Blocks 2–4, there were 15 trials (17 exposures in total).
Chambré et al. (2017)	One to one	Pictures and definitions	Manipulated between subjects	No	Participants saw a picture, were told a name and definition, and then asked to repeat the word. In the no-orthography condition, they repeated the word twice. They then completed nine test trials with corrective feedback. In odd trials, they recalled the pronunciation from a picture. In even trials, they heard a word and provided the definition. Posttests occurred the day after training and 14 days later.
Ehri & Wilce (1979), Study 1	One to one	None	Incidental	No	On the first trial, participants saw visual cues and heard the nonwords and then repeated them. Some children were presented with "adjunct cues" (correct spellings or misspellings), and some were not. They were then presented with the visual cues and asked to recall the word, with corrective feedback and an additional repetition if the response was incorrect. Criterion was all four sounds correct on two successive trials, to a maximum of 15 trials.
Ehri & Wilce (1979), Study 2	One to one	None	Incidental	Yes	On the first trial, participants saw visual cues and heard the nonwords and then repeated them. Some children were presented with "adjunct cues" (correct spellings), and some were not. They were then presented with the visual cues and asked to recall the word, with corrective feedback and an additional repetition if the response was incorrect. Criterion was all four sounds correct on two successive trials, to a maximum of 15 trials.
Ehri & Wilce (1979), Study 3	One to one	None	Explicit	Yes	On the first trial, participants saw and heard the nonwords paired with a numeral (1–4) and then repeated them. Some children were presented with "adjunct cues" (correct written spellings, oral spelling with letter names, oral spelling with phonemes), and some were not. They were then presented with the numerals and asked to recall the word, with corrective feedback and an additional repetition if the response was incorrect. Criterion was all four sounds correct on two successive trials, to a maximum of seven trials.

(*table continues*)

Table 3. *(Continued).*

Authors	Delivery method	Semantic information learnt	Orthography: incidental or explicit	Visual control condition	Procedure
Han & Choi (2016)	One to one	Pictures of novel objects	Explicit	No	On Day 1, adults heard words matched with pictures. They were asked to click on the target pictures and received feedback on accuracy. On Day 2, they completed the same task with three choices instead of two. On Day 3, the learning session was the same as Day 2, and then, words' spellings were presented once.
Hu (2008)	One to one	Pictures	Incidental	Yes	Children saw cartoon figures in an array and heard their names (English pseudowords). They were asked to repeat the names. Words were presented with either their written forms or undecodable symbols. No feedback was given. Pictures were shown again in a different order, and the child was asked to say them again. This process constituted a trial and was repeated until criterion was reached. Criterion was all pictures named correctly on two successive trials, with a maximum of 10 trials.
Jubenville et al. (2014), Study 1	One to one	Pictures of novel objects	Incidental	No	Training started with a repetition block (children heard a name, saw an associated picture, and then repeated the name). They then completed a block in which they were asked to name the pictures. There was a minimum of six and a maximum of nine training cycles. Criterion was three accurate successive production trials. Children received feedback after incorrect attempts. Posttests were carried out the following day.
Jubenville et al. (2014), Study 2	One to one	Pictures of novel objects	Incidental	No	See Jubenville et al. (2014), Study 1
Li et al. (2016)	One to one	Pictures	Incidental	No	Children heard the pictures being named and were asked to remember the names. They were then asked to recall the label without feedback (test trials). Training and test trials were interleaved. Testing was stopped if all 12 pictures were named correctly two trials in a row to a maximum of four trials.
Lucas & Norbury (2014)	One to one	Pictures of objects, prompt question to classify object as animal/plant/ neither	Incidental	No	Children heard a word paired with a picture and were then asked to semantically categorize the words (decide whether they were animals or plants or neither) with feedback. Children saw each stimulus twice. Then, they were asked to name the picture, match the picture to a spoken word, and complete an orthographic choice task.

(*table continues*)

Table 3. *(Continued).*

Authors	Delivery method	Semantic information learnt	Orthography: incidental or explicit	Visual control condition	Procedure
Mengoni et al. (2013)	One to one	Pictures of novel objects	Explicit	Yes	Children saw pictures and heard nonwords, then repeated them, and completed a segmentation activity. They then heard the nonwords again and had to choose a matching picture. Finally, they were asked to name the picture with corrective feedback. This procedure was repeated four times.
Miles et al. (2016)	One to one	Definition sentence, picture, sentences in feedback	Incidental	No	Participants were shown a picture, heard a word in isolation and in a defining sentence, and then repeated the word. Then, four sets of pronunciation trials (participants named pictures with feedback) and meaning trials (participants were asked to recall word meanings with feedback) followed. There was one session for words with spelling and another session for words without spellings. There were five trials per word.
Reitsma (1983), Study 1	One to one	Category (animals or fruit)	Incidental	No	Children saw words and made categorical decisions. They were trained to a criterion of correct classification three times in succession. Posttests occurred 90 min later.
Ricketts et al. (2009)	One to one	Pictures of novel objects	Incidental	No	Children heard the phonological forms of the target words and then repeated them until they could produce the correct pronunciation. They then received six training blocks consisting of three repetition trials (they were asked to repeat the nonwords with feedback) and three production trials (naming with feedback). Children saw each item six times.
Ricketts et al. (2015)	One to one	Pictures of novel objects	Incidental	No	See Ricketts et al. (2009)
Rosenthal & Ehri (2008), Study 1	One to one	Definitions containing synonyms, five meaning-clarifying sentences, pictures depicting meanings of objects	Incidental	No	Students saw a picture, heard the word in isolation and in a defining sentence, and then repeated the word and sentence. They were then exposed to interleaved pronunciation trials (naming with feedback) and definition trials (recalling definitions with feedback in the form of meaning-elaborated sentences). Children completed a minimum of five and a maximum of eight trials—criterion was three perfect consecutive trials with a minimum of five exposures. Posttests took place after a 1-day delay.

(*table continues*)

Table 3. *(Continued).*

Authors	Delivery method	Semantic information learnt	Orthography: incidental or explicit	Visual control condition	Procedure
Rosenthal & Ehri (2008), Study 2	One to one	Definitions containing synonyms, four meaning-clarifying sentences, pictures depicting meanings of objects	Incidental	No	Students saw a picture, heard the word in isolation and in a defining sentence, and then repeated the word and sentence. They were then exposed to interleaved pronunciation trials (naming with feedback) and definition trials (recalling definitions with feedback in the form of meaning-elaborated sentences). Children completed a minimum of six and a maximum of nine trials—criterion was three perfect consecutive trials with a minimum of six exposures. Posttests took place after a 1-day delay.
Saletta, Goffman, & Brentari (2016)	One to one	Pictures of aliens, alien names heard in low-constraint sentence context	No explicit instructions to learn written form, but participants either read or heard the nonword, so the written form was salient in that condition	No	Participants heard each nonword 10 times and then repeated it in its carrier sentence. They then either read each nonword aloud 10 times or repeated it 10 times. Finally, they once again heard each nonword 10 times and repeated it in the carrier sentence.
Saletta, Goffman, & Hogan (2016)	One to one	Pictures of aliens, alien names heard in low-constraint sentence context	No explicit instructions to learn written form, but participants either read or heard the nonword, so the written form was salient in that condition	No	Participants heard each nonword 10 times and then repeated it in its carrier sentence. They then either read each nonword aloud 10 times or repeated it 10 times. Finally, they once again heard each nonword 10 times and repeated it in the carrier sentence.
Savaiano et al. (2015)	One to one	Word in sentence context and verbal definition	Explicit	No	Students were told the pronunciation for the target word and were asked to repeat it. They then heard the word in a sentence and heard its definition and were asked to repeat the definition. Criterion was at least 12 out of 18 items correct three times in a row.

(*table continues*)

Table 3. *(Continued).*

Authors	Delivery method	Semantic information learnt	Orthography: incidental or explicit	Visual control condition	Procedure
Vadasy & Sanders (2015)	One to one	Words were heard in story contexts, and children were given definitions.	Explicit	No	Six stories were read over 6 days. Target words appeared three times per story, with a total of nine exposures per word. Words were defined the first time they appeared in the story. In the definitions-plus condition, children also saw a card with the printed word on it. The child was asked to pronounce the word, spell it aloud, and say it again. Posttests were administered the week after instruction ended.
Valentini et al. (2018)	One to one	Children were exposed to words in stories. Half the words were presented with definitions and half without. Contextual information in the passage gave clues to word meaning.	Incidental	No	Children were exposed to words embedded in stories twice, 1 week apart. Posttests were conducted immediately after the second exposure. Words were embedded in the stories (half with definitions, half without), and children either read the stories from a booklet, listened via headphones, or both.

Table 4. Findings.

Authors	Research question(s)	Outcome measures	Orthographic facilitation (OF) observed?	Better readers benefited more?	Other information
Baron et al. (2018)	Do children with dyslexia benefit from OF?	Phonological–visual linking task (learning phase), naming task	Yes, but slight difference in time course of the effect across the groups. Children with dyslexia showed effects a trial earlier.	No	Did not look at correlations between word reading and degree of orthographic facilitation because the sample was selected to represent two distinct reading ability groups.
Chambré et al. (2017)	Will first graders benefit from OF? Will directing attention to print increase effects? Will more advanced readers benefit more?	Picture naming, picture spelling, definitions	Yes, on learning of phonological and orthographic forms	Yes, on phonological and orthographic measures	Participants very close to ceiling on semantic posttests. Difference between groups on meanings task was marginal at 14-day posttest.
Ehri & Wilce (1979), Study 1	Will the presence of correct spellings help children learn sounds?	Naming in response to cue, number of trials to criterion (max. 15)	Yes, on number of trials to criterion	Yes, better readers needed fewer trials	NA
Ehri & Wilce (1979), Study 2	Will the presence of correct spellings help children learn sounds?	See Ehri & Wilce (1979), Study 1	Yes, on number of trials to criterion	Yes, better readers needed fewer trials	NA
Ehri & Wilce (1979), Study 3	Will the presence of correct spellings help children learn sounds?	No, correct sounds recalled on each trial	Yes	NA	NA
Han & Choi (2016)	Does exposure to different spellings influence adult speech production and spelling?	Word–picture matching, picture naming during learning and at posttest, spelling posttest	No, but adults were at ceiling after Day 3 of training. Presence of orthography did influence spelling choice on spelling task.	NA	Participants were either exposed to no spelling or to one of two variant spellings for a phoneme that can be pronounced in multiple ways within a word.
Hu (2008)	Does the presence of orthography benefit word learning in Chinese-speaking children learning English?	Repetition during learning, picture naming during learning, word–picture matching (if child could not produce correct labels after 10 trials)	Yes, for both high– and low–phonological awareness (PA) groups on picture naming	NA	Advantage in orthography-present condition was smaller for those with poor PA and appeared in later trials. Children were assigned to PA groups 2 years before the study itself, so differences between groups should be interpreted with caution.
Jubenville et al. (2014), Study 1	Do monolingual French-speaking children benefit from OF? Is the effect modulated by spelling–sound consistency?	Picture naming during learning and at posttest, word–picture matching and spelling to dictation at posttest	Yes, on picture naming at both time points. Word–picture matching was near ceiling.	NA	Participants were assigned to either a no-print condition, a consistent print condition, or an inconsistent print condition. Children in the consistent condition produced the most labels for the novel words.
Jubenville et al. (2014), Study 2	Do bilingual French-speaking children benefit from OF? Is the effect modulated by spelling–sound consistency?	See Jubenville et al. (2014), Study 1	Yes, on picture naming at both time points	NA	For bilingual participants, children in the inconsistent condition produced the most labels for the novel words.

(*table continues*)

Table 4. *(Continued).*

Authors	Research question(s)	Outcome measures	Orthographic facilitation (OF) observed?	Better readers benefited more?	Other information
Li et al. (2016)	How is word learning influenced by the presence of orthography in children who speak and read Chinese benefit?	Picture naming during learning, monosyllable picture matching	Yes, later in training for semantically accurate characters on picture naming. Misleading characters interfered with learning.	NA	NA
Lucas & Norbury (2014)	Do children with autism spectrum disorder (ASD) benefit from orthographic facilitation?	Picture naming, spoken word–picture matching, orthographic choice	Yes, for picture naming and orthographic choice. Orthographic facilitation for spoken word–picture matching was only observed for the participants with ASD.	NA	Participants' eye movements were tracked during learning. Both groups fixated on the written form to the same extent, but children with ASD looked longer in the word region in the orthography-absent condition (i.e., when the word was not there), suggesting they may have sought the additional cue to learning.
Mengoni et al. (2013)	Do children with Down syndrome benefit from orthographic facilitation?	Picture naming during training and at posttest	Yes	NA	In the orthography-absent condition, Greek or Cyrillic letters were included as a check of whether the presence of an additional visual cue could account for facilitation effects. Performance was superior in the orthography-present condition.
Miles et al. (2016)	Do monolingual and language minority college students benefit from OF?	Prompted pronunciation recall during learning, prompted recall of definition during learning, spelling production	Yes, for pronunciation recall and spelling production. No facilitation seen for definition recall, but scores were at ceiling.	NA	Both monolinguals and language learners benefited from orthographic facilitation, though the language learners performed more poorly than native speakers in both conditions.
Reitsma (1983), Study 1	Do Dutch-speaking children learn words faster when orthography is present?	Semantic categorization of written words	Yes	NA	NA
Ricketts et al. (2009)	Do children benefit from the presence of orthography during word learning? Is this influenced by reading ability or spelling–sound consistency?	Picture naming during training, nonword–picture matching, spelling	Yes, for all measures except spelling of consistent items (facilitation was seen for spelling of inconsistent items)	Yes, reading ability correlated with orthographic facilitation.	Presence of orthography did not affect spelling of consistent items but did improve spelling of inconsistent items.
Ricketts et al. (2015)	Do children with developmental language disorder (DLD) and autism spectrum disorder (ASD) benefit from OF?	See Ricketts et al. (2009)	Yes, but effect for nonword–picture matching was marginal.	No	NA

(*table continues*)

Table 4. *(Continued).*

Authors	Research question(s)	Outcome measures	Orthographic facilitation (OF) observed?	Better readers benefited more?	Other information
Rosenthal & Ehri (2008), Study 1	Do second graders benefit from the presence of orthography during word learning? Is this influenced by their reading abilities?	Prompted pronunciation recall during learning, prompted recall of definition during learning, posttests of word and spelling production, word–sentence recognition matching	Yes, on all measures except word–sentence matching, where performance was at ceiling. Facilitation was greater for pronunciations than for definitions.	Yes, reading ability correlated with pronunciation recall in both spelling-present and spelling-absent conditions	Definitions recalled more easily than pronunciations, but effect became smaller across trials.
Rosenthal & Ehri (2008), Study 2	Do fifth graders benefit from the presence of orthography during word learning? Is this influenced by their reading abilities?	Prompted pronunciation recall during learning, prompted recall of definition during learning, oral cloze task, posttests of pronunciation, spelling and definition production, meaning recognition	Yes, on all measures except word–sentence matching, where performance was at ceiling. Facilitation was greater for pronunciations than for definitions.	Yes, for learning pronunciations	Participants were divided into two groups of better and weaker readers based on the Boder Test of Word Reading, which showed a bimodal distribution of scores. Number of syllables in the nonword influenced recall of pronunciations but not definitions.
Saletta, Goffman, & Brentari (2016)	Does the presence of a word's written form during learning influence speech production in adults? Is this affected by spelling transparency or reading ability?	Percentage of consonants correct, articulatory stability (lip aperture variability)	Yes, advantage for percentage of consonants correct in both orthography-present (transparent and opaque) conditions	NA—OF effect was only observed on percentage of consonants correct, and correlation with reading ability was not calculated for this measure.	No effect of orthographic transparency. There was no advantage for the presence of orthography on the lip aperture variability measure, though there was an overall correlation between reading ability and greater stability in speech production.
Saletta, Goffman, & Hogan (2016)	Does the presence of a word's written form during learning influence speech production in typically developing children and in adults with high or low levels of reading proficiency?	See Saletta, Goffman, & Brentari (2016)	Yes, for percentage of consonants correct. Orthographic facilitation was found for both transparent and opaque orthography-present conditions compared to the orthography-absent condition. For the articulatory stability measure, there was no difference across conditions for typically developing adults or children, but poor reader adults showed greatest improvements in stability in the transparent orthography condition.	No, though there was an effect of transparency for only poor reader adults on the articulatory stability measure.	Participants were not exposed to written and orthographic forms simultaneously. They heard auditory forms in the first phase and later either read or heard the nonword. Adult poor readers had good comprehension skills relative to their decoding skills.

(*table continues*)

Table 4. *(Continued).*

Authors	Research question(s)	Outcome measures	Orthographic facilitation (OF) observed?	Better readers benefited more?	Other information
Savaiano et al. (2015)	Do children who read Braille benefit from OF?	Spelling, verbal definition task, children asked to explain what a word meant in a sentence	Yes, for Braille spellings but not for definitions	NA	First study of vocabulary instruction in Braille readers. No statistical analyses.
Vadasy & Sanders (2015)	Do English learners in kindergarten benefit from OF when learning words from story reading?	Multiple-choice word–picture matching, definitions, spelling	Yes, for spelling, with a trend toward significance for definitions.	NA	There was a trend for greater expressive vocabulary gains in the orthography-present condition for students who had better vocabulary scores.
Valentini et al. (2018)	Do children learn words better from stories when they hear the story, see the story, or both see and hear the story? Does the presence of a definition improve word learning?	Phonological and orthographic posttests (two-alternative forced choice), semantic posttests (category recognition, subcategory recognition, definition choice, multiple-choice story comprehension)	Advantage for orthographic learning in visual and visual + auditory groups over auditory group, but no evidence of orthographic facilitation for phonological learning. Performance on the category recognition task was superior in the auditory + visual condition, but there was no evidence of facilitation on the other semantic tasks.	No	NA

Note. NA = Not Applicable.

2014; Reitsma, 1983; Ricketts et al., 2009; Rosenthal & Ehri, 2008; Valentini et al., 2018) and two found marginal differences between orthography-present and orthography-absent conditions (Ricketts et al., 2015; Vadasy & Sanders, 2015; see Table 4).

Two studies found no evidence of orthographic facilitation. One of these used Braille for the "orthography-present" condition with visually impaired readers (Savaiano et al., 2015), which may not be equivalent to orthography in this context. In the other study (Chambré et al., 2017), participants' mean scores were high during training (5.04 of a total of 6 for the spelling exposure group and 4.79 for the no-spelling group) and very close to ceiling at both of the posttests. It is possible that there was not sufficient variability in scores to detect a difference between the groups. Indeed, as mentioned above, ceiling effects were also an issue in four other studies. These ceiling effects may reflect methodological challenges. It is difficult to find a balance between including sufficient numbers of items so that it is possible to detect differences between groups, and keeping the number of items to a reasonable amount so that participants can feasibly be expected to learn them.

Within the eight studies that did find evidence for orthographic facilitation in semantic learning, the magnitude of the effect varied from marginal to strong. The studies included sample sizes of between 16 and 92 participants and between 4 and 20 items, with Reitsma (1983) including the smallest number of participants and Baron et al. (2018) including the smallest number of items (see Tables 1 and 2). However, the strength of effects did not vary systematically with the number of participants or items, indicating that smaller effects were not driven entirely by lack of power.

Across these studies, different training methods were also used (see Table 3). These ranged from teaching simple associations between pictures and labels (e.g., Baron et al., 2018; Ricketts et al., 2009) to exposing children to words in the context of meaningful stories (e.g., Vadasy & Sanders, 2015; Valentini et al., 2018). This demonstrates that orthographic facilitation for semantic learning can occur in a variety of learning situations. However, there was no clear relationship between the magnitude of the effect and the type of training used. For example, medium to large effects were found in a study in which children learnt definitions and heard words in sentence context (Rosenthal & Ehri, 2008) and in a study in which children learnt much simpler semantic information (associations between words and pictures and semantic categorization; Lucas & Norbury, 2014). By contrast, one study using a picture–word association learning paradigm showed a significant orthographic facilitation effect for semantic learning (Ricketts et al., 2009), but another study using the same paradigm found only a marginal effect (Ricketts et al., 2015).

As noted above, outcome measures for the eight studies also varied. These included word–picture matching, semantic categorization, verbal definition tasks, and multiple-choice definition recognition tasks (see Table 4). There was some indication that recognition tasks (i.e., word–picture matching) were more susceptible to ceiling effects than production tasks (i.e., definition tasks)—of the 11 studies utilizing recognition tasks, four showed ceiling effects, whereas none of the studies using definition tasks showed ceiling effects. However, when ceiling effects were not present, effect sizes ranged from small to large regardless of whether measures required recognition (i.e., word–picture matching) or production (i.e., definition tasks; Ricketts et al., 2009, 2015; Rosenthal & Ehri, 2008; Vadasy & Sanders, 2015).

It is difficult to disentangle the impact of the tasks used from other aspects of study design, such as the number of participants and items or the method of training. Indeed, even studies that used the same outcome measure (e.g., word–picture matching) used different stimuli, training procedures, and so on. Overall, there is some evidence that the presence of orthography benefits semantic learning, but questions remain about the circumstances under which this occurs. In order to isolate factors that predict the magnitude of the orthographic facilitation effect, studies that systematically manipulate sample sizes, items, training procedures, and outcome tasks are needed.

Who Benefits From Orthographic Facilitation?

The majority of studies have explored orthographic facilitation in typically developing, monolingual populations. However, a handful of studies have explored this effect in other populations, with at least some orthographic facilitation effects observed in all studies. Orthographic facilitation effects on phonological learning have been found for samples of children with DLD (Ricketts et al., 2015) and Down syndrome (Mengoni et al., 2013), children with diagnoses of ASD (Lucas & Norbury, 2014; Ricketts et al., 2015), poor readers and those with poor phonological awareness (Baron et al., 2018; Hu, 2008; Saletta, Goffman, & Hogan, 2016), and second language learners or bilingual children and adults (Hu, 2008; Jubenville et al., 2014; Miles et al., 2016). Effects on orthographic learning have been found for bilingual children (Jubenville et al., 2014), adult English language learners (Miles et al., 2016), children with ASD (Lucas & Norbury, 2014; Ricketts et al., 2015), children with DLD (Ricketts et al., 2015), and children with visual impairment learning Braille (Savaiano et al., 2015), though the latter study was a case series involving only three participants. No studies with participants who were poor readers included a measure of orthographic learning (see Tables 1 and 4). Finally, marginal effects on semantic learning were found for children with ASD and DLD in Ricketts et al. (2015), and significant effects were found for children with ASD in Lucas and Norbury (2014). Marginal effects on semantic learning for children who were second language learners of English were also found in Vadasy and Sanders (2015).

It is worth considering whether better readers benefited more from orthographic facilitation than poorer readers, who might be expected to have a weaker grasp of the links between spellings and sounds. Only two studies have directly

compared children or adults with reading difficulties to typical readers. These studies found that both good and poor readers were able to benefit from orthographic facilitation, though there were differences between the groups in time course (Baron et al., 2018) and effects of spelling–sound consistency (Saletta, Goffman, & Hogan, 2016; see Table 4). A number of other studies have compared relatively good to relatively poor readers within their samples or calculated correlations between reading ability and scores on learning measures. Two of these studies (Ricketts et al., 2015; Valentini et al., 2018) did not find any evidence that better readers benefited more from orthographic facilitation, but six studies did find evidence of this (see Table 4). In particular, Ehri and Wilce (1979) found that beginning readers with very poor knowledge of printed words struggled to learn sound–symbol pairings, even when aided by the presence of accurate spellings, and Chambré et al. (2017) noted that some of the weakest readers in their study did not show an orthographic facilitation effect. Overall, there is evidence to suggest that orthographic facilitation can benefit beginning readers and those with reading difficulties, but this may not be true for the weakest readers.

In summary, there is evidence that orthographic facilitation can support vocabulary acquisition in children with ASD, DLD, and Down syndrome as well as second language learners. There is mixed evidence when it comes to the question of whether better readers benefit more than poor readers. Importantly though, orthographic facilitation can occur even for children with limited orthographic knowledge, as seen in children with dyslexia (Baron et al., 2018), those with DLD (Ricketts et al., 2015), and beginning readers (Chambré et al., 2017). This suggests that, once some knowledge of orthography has been acquired, the use of orthography is likely to be a useful strategy for supporting word learning.

Studies with special populations are few and have particularly small sample sizes. Furthermore, the participants in these studies are chosen to meet particular selection criteria and are not necessarily representative of the wider populations from which they are drawn. For example, in Baron et al. (2018), participants with dyslexia were selected to have age-appropriate oral language skills, but many children with dyslexia have oral language weaknesses. In Ricketts et al. (2015), participants with DLD and ASD were matched to typically developing participants for age and nonverbal IQ, but on average, children with DLD and ASD tend to have lower nonverbal IQ scores than typically developing children of the same age. Therefore, while the results of these studies are promising, they should be interpreted with caution.

When Is Orthographic Facilitation Observed?

Incidental or Explicit Exposure to Orthography

In 15 of the 23 studies, orthography was displayed incidentally during the learning process (in other words, participants saw the words during the learning task but were not instructed to pay attention to them). In five studies, participants were explicitly told to pay attention to orthographic forms (see Table 3), and in one study (Chambré et al., 2017), explicitness of instructions was manipulated between participants. In the remaining two studies (Saletta, Goffman, & Brentari, 2016; Saletta, Goffman, & Hogan, 2016), participants were not given any explicit instructions to pay attention to orthography, but the comparison was between trials in which a picture was presented with either the orthographic form or the phonological form (never both), so the orthographic forms of the words would have been very salient in the orthography-present condition.

Regardless of whether exposure to orthography was incidental or explicit, orthographic facilitation for at least one outcome measure was observed on all studies except one (Han & Choi, 2016), where participants were at ceiling. In the study in which explicitness of instructions was manipulated between participants (Chambré et al., 2017), explicit instructions to pay attention to the written form of the word provided no additional benefit to learning, and in fact, the mean scores for the implicit group were higher than those for the explicit group (though the differences were not statistically significant). Thus, orthographic facilitation seems to occur regardless of whether or not attention is drawn to a word's written form, which suggests that it is a relatively automatic process for those with at least some decoding knowledge: Studies included children as young as 6 years old and participants with dyslexia whose nonword reading fluency standard scores were as low as 65.

Stimulus Characteristics

In the majority of studies (17 of 23), participants were taught nonsense words or nonsense names for novel objects or characters. Using nonsense word stimuli limits the influence of prior knowledge. In the remaining studies, participants were taught low-frequency real words they were unlikely to know. Orthographic facilitation for at least one outcome measure was observed, regardless of whether words or nonsense words were taught. This indicates that orthographic facilitation occurs for "words" that we know are unfamiliar to the learners (nonsense words) and in the more naturalistic case of learning real words. In most of the studies, participants were taught words or nonsense words that followed regular letter–sound correspondences. This is discussed in more detail below.

Training Delivery

In all of the studies, training was administered one-on-one and was usually computer-administered or delivered manually by researchers or research assistants. The only exception was the study by Vadasy and Sanders (2015), in which training was administered by experienced reading tutors who worked in local schools. Overall, studies of orthographic facilitation had low levels of ecological validity—they did not represent typical situations under which children and adults encounter new words.

What Is the Mechanism Driving Orthographic Facilitation?

Is the Effect Orthographic or Visual?

Improved learning for the orthography-present condition relative to the orthography-absent condition may not reflect orthography per se. Instead, because the orthography-present condition has an additional visual cue, it may be a more general visual effect. Two studies have addressed this issue. In Mengoni et al. (2013), children with Down syndrome and younger typically developing children matched for word reading abilities learnt the names of novel objects. These words were presented either with their orthography or with Greek or Cyrillic letters children had never seen before. Performance was superior in the orthography condition. In Hu (2008), Chinese-speaking children who were English language learners were taught English names for novel characters. Children were divided into two groups—those with weaker phonological awareness and those with stronger phonological awareness (though note that phonological awareness was measured 2 years before the study itself). During learning, children saw either the English orthographic forms of the words or nondecodable symbols. There was an advantage for words learnt with orthographic forms for both high– and low–phonological awareness groups.

Evidence from these two studies supports the view that the presentation of visual information alone is not sufficient to trigger facilitation effects and that some degree of systematicity in the relationships between spellings and sounds or meanings is likely to be necessary for orthographic facilitation to occur. However, it is important to consider the possibility that the presence of nonorthographic visual information could actually confuse or distract learners and thereby suppress word-learning performance (Lucas & Norbury, 2014; Ricketts et al., 2015). This possibility has not yet been directly tested.

Systematicity of Spelling–Sound Relationships

Orthographic facilitation may occur because learners take advantage of systematic mappings between orthography and phonology. If so, we would expect orthographic facilitation to be more marked for words with consistent (i.e., predictable) than inconsistent spellings (Jubenville et al., 2014). On the other hand, English has many words that contain inconsistent or unpredictable grapheme–phoneme (spelling–sound) relationships. For inconsistent words, spelling patterns cannot be inferred from phonology and can only be learned if they have been seen. Therefore, it is possible that orthographic facilitation may in fact be stronger for inconsistent than consistent items, and indeed, this has been demonstrated in two studies (Jubenville et al., 2014; Ricketts et al., 2009). Overall, very few studies have manipulated grapheme–phoneme consistency with the intention of investigating whether orthographic facilitation is greater for consistent items. Nonetheless, six studies have included items that allow us to examine the degree to which orthographic facilitation relies on systematic mappings between orthography and phonology (see Table 2).

When investigating phonological learning, Saletta and colleagues have shown orthographic facilitation to be greater for consistent than inconsistent items, but only for adult poor readers and not for able adult and child readers (Saletta, Goffman, & Brentari, 2016; Saletta, Goffman, & Hogan, 2016). For semantic learning, findings are similarly mixed. In Ricketts et al. (2009), whereas orthographic facilitation was greater for inconsistent than consistent items on the measure of orthographic learning, the degree of orthographic facilitation on the semantic learning measure was equivalent for both consistent and inconsistent items (this was not analyzed in Ricketts et al., 2015). Consistency was manipulated over a particularly small number of items, which may have limited the effect. With a greater number of items, Jubenville et al. (2014) observed more pronounced orthographic facilitation for consistent than inconsistent items for French-speaking monolingual children, but the reverse (more orthographic facilitation for inconsistent than consistent items) for French–English bilingual children. The authors suggested that bilingual children may have paid more attention to the inconsistent words because the pattern of inconsistency was rare and therefore salient.

Overall, there is no consensus as to the effects of orthographic consistency in alphabetic languages. Li et al. (2016) conducted a study that touched on the issue of consistency in a nonalphabetic language. They taught participants Chinese characters in which phonological and semantic consistency were manipulated. Children's word learning performance benefited from exposure to characters that gave semantically accurate cues, compared to words learnt without any orthography (there was no facilitation for phonologically accurate characters). Conversely, performance was impaired when children saw phonologically and semantically misleading characters.

The combined findings from these studies suggest that, in order for orthographic facilitation to occur, there must be at least some degree of systematicity in the relationship between the visual form and the spoken form or meaning of the word. However, the evidence does not support a strong claim that orthographic facilitation always relies on links between orthography–phonology mappings at the grapheme–phoneme level—orthographic facilitation can occur even in a nonalphabetic language and for items with inconsistent spelling–sound relationships. Future studies are needed to explore this issue further.

Discussion

In this article, we set out to synthesize existing evidence in order to determine whether exposure to the presence of a word's written form facilitates lexical learning. We conducted a systematic review, identifying 23 studies that were carried out with different populations of learners, and used a variety of training methods and outcome measures. Despite the different methods used and the fact that

sample sizes were generally small, the studies provided consistent evidence that the presence of orthography does improve learning of orthographic and phonological forms. There was also some evidence that it improves semantic learning.

Why does orthographic facilitation occur? Evidence from a number of studies (e.g., Hu, 2008; Li et al., 2016; Mengoni et al., 2013) supports the view that orthographic facilitation is not simply a visual effect. In alphabetic languages, it seems likely that orthographic facilitation is driven, at least to some extent, by knowledge of grapheme–phoneme relationships (Ricketts et al., 2009; Rosenthal & Ehri, 2008). However, orthographic facilitation has been found on words with inconsistent grapheme–phoneme correspondences (e.g., Ricketts et al., 2009), and there is evidence from a small number of studies that children and adults can benefit from orthographic facilitation even when they have a limited amount of spelling–sound or orthographic knowledge, either because they are novice readers (e.g., Ehri & Wilce, 1979) or because they have reading difficulties (e.g., Baron et al., 2018; Saletta, Goffman, & Hogan, 2016). Furthermore, orthographic facilitation has been demonstrated in a nonalphabetic language (Chinese), when characters contained consistent cues to semantic information (Li et al., 2016). Therefore, systematicity in grapheme–phoneme relationships does not seem to be the sole mechanism driving orthographic facilitation. Further work is required to explore how adults and children use orthographic information to facilitate learning of word forms.

As mentioned above, the findings for an orthographic facilitation effect on semantic learning were more mixed than findings relating to phonological and orthographic learning. It is interesting to consider why studies may find different results. One possibility is that studies used different training methods and a variety of outcome measures; however, no clear pattern emerged as to which types of training were more likely to result in an orthographic facilitation effect or which types of outcome measures were most sensitive to detecting the effect. It is important to note that participants seem to find it comparatively easy to learn simple semantic information (such as word–picture associations or brief definitions) from short-term training paradigms. Therefore, it seems to be difficult for experimental designers to judge how much training is sufficient for learning to occur, without resulting in ceiling effects.

Given that a number of studies did find an effect of orthographic facilitation on semantic learning, it seems likely that the presence of orthography does play a role in the early stages of semantic learning, helping participants form episodic memories for word meanings (e.g., see Valentini et al., 2018). However, it is unclear whether this knowledge could be retrieved in different contexts. It is also not clear what role orthography plays in longer term retention or retrieval, as the majority of studies assessed participants' word learning immediately after instruction, and there was only one study (Chambré et al., 2017) that included a follow-up period of longer than 1 day.

It is also relevant that, in the majority of studies, the type of semantic knowledge learnt was very shallow. Word learning in everyday life is more complex than learning word–picture associations or short definitions, and indeed, such knowledge is unlikely to be helpful in an everyday context, such as attempting to understand a written word in context (e.g., Beck, McKeown, & Kucan, 2002). The choice to teach relatively simple semantic information has practical advantages in terms of study design, but it is unclear whether findings will generalize to more complex word learning situations. This statement also holds true when we consider that, in the studies reviewed here, ecological validity was low—learning always took place in a one-on-one situation. In real life, if children do experience vocabulary instruction, it is likely to be in a classroom or small-group situation—one-on-one instruction is seldom feasible or cost-effective. To date, no published studies have explored whether orthographic facilitation is observed in group learning situations. Furthermore, evidence of orthographic facilitation effects is relatively sparse in populations who have reading or word learning difficulties (such as children with DLD, dyslexia, ASD, or Down syndrome). However, the studies that do exist have shown promising results, indicating that more research with these populations is warranted.

Clinical Implications

Although more questions remain to be answered, the findings of our systematic review suggest that the presence of the written form during word learning is likely to be beneficial for beginning readers and English language learners, as well as children with DLD, reading difficulties, ASD, and Down syndrome. Current research shows that it is not necessary to draw attention to the word's written form, but it should be clearly visible during the learning process. However, it is worth noting that the presence of a word's written form may not be beneficial for those who have extremely low levels of reading ability. Assuming that learning to read is a functional and realistic goal, individuals with very poor reading abilities are likely to require additional instruction in spelling–sound relationships before they can benefit from orthographic facilitation (e.g., Miles, McFadden, & Ehri, 2018).

Conclusions

There is still much more to learn about the mechanisms behind the orthographic facilitation effect and about how the presence of orthography influences semantic learning. However, the effect has been replicated in a wide range of experimental studies, and existing evidence does support the presentation of a word's written form during learning. Given this evidence base, the time has now come to explore orthographic facilitation in more realistic word-learning situations, with more diverse populations. Classroom observations show that teachers do emphasize orthographic forms when they are introducing new spoken

words (Ricketts et al., 2015). However, this practice is not used universally or systematically in vocabulary instruction or intervention approaches. There is a need for researchers to collaborate with educators and clinicians to determine the best way to take advantage of this effect for improving the vocabulary knowledge of both children and adults.

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