Orthographic Support for Word Learning in Clinical Populations: A Systematic Review

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Abstract

Purpose: A systematic review was performed to determine the extent to which orthographic facilitation, a strategy to improve word learning, has been demonstrated in the literature for children and adolescents from clinical categories such as Developmental Language Disorders (DLD), Autism Spectrum Disorders (ASD), Down syndrome, dyslexia, hearing impairment, intellectual disability, and cerebral palsy.

Method: Five databases were searched for all studies published through December 2019. Eligible studies included participants from a clinical population (DLD, ASD, dyslexia, cerebral palsy, Down syndrome, hearing impairment, etc.) and compared word learning with and without orthography. Selected studies were extracted for pertinent information. In addition, assessment of the methodological rigor was performed for each study.

Results: The review yielded five studies that targeted word learning with orthographic facilitation for children from various clinical populations including DLD, verbal children with autism, Down syndrome, and dyslexia. All studied populations showed a benefit for word learning in picture naming posttests when words were trained in the presence of orthography.

Conclusions: For the studied populations, training words in the presence of orthography will improve word learning accuracy and retention. The review highlights the need for more research in this area across other clinical populations.

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Key Words: Word learning, orthography, developmental language disorder

A Systematic Review of the Literature on Orthographic Support for Word Learning in Clinical Populations

Vocabulary contributes significantly to a child's reading comprehension skills (National Reading Panel, 2000) and overall academic skills, particularly past third grade (Biemiller, 2003). Direct instruction of targeted vocabulary items increases reading comprehension and is one instructional strategy used in classrooms (e.g., Archer & Hughes, 2010; Beck & McKeown, 2007). Showing a word's orthographic representation during learning activities has been shown to facilitate word learning for typically developing (TD) children (e.g., Ehri & Wilce, 1979; Jubenville et al., 2014; Nelson et al., 2005; O'Leary, 2017; Ricketts et al., 2009; Rosenthal & Ehri, 2008; for review, see Colenbrander et al., 2019). This paper aims to systematically review the literature for studies that compare vocabulary learning with and without the support of orthography for children and adolescents from clinical populations, such as Developmental Language Disorder (DLD)[1], Intellectual Disabilities, Autism Spectrum Disorder (ASD), Down syndrome, Hearing Impairment, Cerebral Palsy, and Dyslexia.

Vocabulary Deficits in Developmental Language Disorder and Other Clinical Categories

It is important to determine ways in which clinicians can improve the vocabulary of children and adolescents with DLD as these individuals frequently underperform on vocabulary tasks when compared to age-matched peers (for review see, Rice et al. 2005).

[1] There has been a recent consensus in the field to use the term DLD to describe children who are school-age and present with language impairment (see Bishop et al., 2017). DLD will be used to describe these children throughout this article, while remaining cognizant of the fact that specific language impairment (SLI) has also been used to describe these children in the past. As DLD is an umbrella term that is inclusive of SLI, both DLD and SLI were used in the search strategy for this systematic review (see Volkers, 2018).

Children with DLD across the school-age years show consistent deficits in the number of vocabulary words known and the depth of the definitions provided (McGregor et al., 2013). This deficit in vocabulary breadth persists through at least the 10th grade, indicating that vocabulary development may be an important goal throughout the school years for children with DLD (McGregor et al., 2013).

Children with DLD do not just have a deficit in the number of words stored, but they also have difficulty with learning novel words (e.g., Gray, 2003). They learn fewer novel words in the same amount of time when compared to age-matched TD children (Gray, 2003; for review, see Kan & Windsor, 2010). In addition, it takes children with DLD more trials to meet criterion for learning novel words. Children with DLD required approximately twice as many trials to learn to comprehend and produce novel words as TD children (Gray, 2003). This difference is even greater for novel verb learning when compared to noun learning (Alt et al., 2004). Because of the vocabulary deficits observed in children with DLD, it is necessary to determine what interventions can improve word learning abilities of those struggling to learn and store novel vocabulary items.

Children and adolescents from other clinical populations have known difficulties with vocabulary skills as well (Alt et al., 2017; Convertino et al., 2014; Mei et al., 2016; Tager-Flusberg & Kasari, 2013; Ypsilanti et al., 2005). Sixty percent of children with cerebral palsy have a language disorder (Mei et al., 2016) while between 33-55% of children with autism fail to develop functional language (Tager-Flusberg & Kasari, 2013). Children with hearing loss have reduced vocabulary outcomes compared to hearing-age matched peers (Convertino et al., 2014). Those with intellectual disabilities can demonstrate wide ranges of ability with regards to vocabulary, with some children (e.g., with Williams syndrome) exhibiting strengths in the area of vocabulary, while others (e.g., Down syndrome) demonstrating weaknesses in the areas of vocabulary production and morphosyntax (Ypsilanti et al., 2005). For children with dyslexia and no language impairment, word learning can be difficult as well, particularly for tasks which tax phonology such as picture naming (Alt et al., 2017). For speech-language pathologists (SLPs) working in school settings, it is within the scope of practice to treat children with a wide variety of disorders for a wide variety of communication impairments (ASHA, 2010). Thus, it is imperative that SLPs have tools to help with vocabulary instruction as many clinical populations have been shown to have deficits in this area.

Vocabulary Learning with Orthographic Support for Typically Developing Children

The term orthographic facilitation refers to the fact that TD children and adults benefit from the presence of orthography or written words when learning new vocabulary (e.g., Chambre et al., 2017; Ehri & Wilce, 1979; Jubenville et al., 2014; Nelson et al., 2005; O'Leary, 2017; Ricketts et al., 2009; Rosenthal & Ehri, 2008). Studies have shown that even children in the partial alphabetic phase (Chall, 1983) of reading development were able to learn words more efficiently and effectively when presented with the words' orthographic representation during learning trials (O'Leary, 2017). This benefit has also been established for TD first- and second-grade students with an orthography-present condition resulting in better word naming (Chambre et al., 2017; Ricketts et al., 2009; Rosenthal & Ehri, 2008), spelling (Chambre et al., 2017; Ricketts et al., 2009; Rosenthal & Ehri, 2008), and spoken word to picture matching (Ricketts et al., 2009; Rosenthal & Ehri, 2008) in post-tests. In addition, in experiments which manipulate the presence of orthography, those with higher word reading ability derive more benefit from the presence of orthography in picture naming post-tests (Chambre et al., 2017; Ricketts et al., 2009; Rosenthal & Ehri, 2008). To determine if students would garner more benefit if directed to attend to the orthography, Chambre and colleagues (2017) tested the difference in learning between drawing attention to the orthography and presenting the orthography but not pointing it out. Drawing attention to the orthography did not result in any additional benefit; in fact, for post-tests completed one day after learning, picture naming and spelling were worse when attention had been drawn to the orthography than when it had not (Chambre et al., 2017). The orthographic facilitation effect has also been observed in 3rd grade monolingual and bilingual speakers (Jubenville et al., 2014).

Theoretical Considerations

Orthographic facilitation is hypothesized to be effective for word learning according to both the lexical quality hypothesis (Perfetti & Hart, 2002) and the dual-coding theory (Clark & Paivio, 1991; Sadoski, 2005). The lexical quality hypothesis stipulates that high-quality representations which include phonological, orthographic, and semantic information will be retrieved more efficiently than those coded with low quality representations. For example, an individual who has stored words with fully specified orthographic, phonological, and semantic-syntactic representations will be able to retrieve these words effortlessly in a way that promotes comprehension and production. The better the quality of the input, the more easily the word will be activated. On the other hand, the same individual may have some words stored with imprecise representations or representations in only one domain; these words will be processed and activated inefficiently. Thus, less skilled readers will have lower quality orthographic representations resulting in a lower quality lexical representation. Readers who have more experiences with orthographic representations will have higher quality lexical representations. Integrating representations in the phonological, orthographic, and semantic domains results in effortless, context-independent word reading and reading comprehension (Perfetti & Hart, 2002).

Even for children with only a rudimentary understanding of letter-sound correspondence, regularities between orthography and phonology affect outcomes (Apel et al., 2013). Just as children are capable of “fast mapping” novel words, so are they able to acquire mental graphemic representations when presented with spellings. Apel and colleagues (2013) presented 12 nonwords four times each during a storybook read aloud task. The nonwords varied in both orthotactic probability (probability of letter combinations) and phonotactic probability (probability of sound combinations). Children were able to produce spellings and identify spellings with greater than chance accuracy, indicating that children quickly acquire mental graphemic representations when only briefly presented with a written word. Using eye-tracking technology, the researchers found that children fixated for longer durations on the nonwords, particularly when those words were in the low orthotactic probability condition. Thus, kindergarten-aged children attend to orthotactic regularities of written words and are capable of acquiring mental graphemic representations after only a brief presentation (Apel et al., 2013). Quickly acquired mental graphemic representations may provide a mechanism through which orthographic facilitation of word learning [is possible.

Additionally, the dual-coding theory specifies that concepts are encoded in both a verbal and a nonverbal form (Clark & Paivio, 1991). Concrete words are encoded by both a web of language (i.e., a verbal code) and by mental imagery (i.e., a nonverbal code) whereas abstract words are only encoded by a semantic web. By teaching concrete vocabulary with both a picture and the orthographic representation, a child will be able to access both the nonverbal and verbal code for that word. To improve vocabulary learning, providing scaffolding that fosters encoding in both verbal and nonverbal forms, such as photographs with orthography, will result in better and faster retention of novel words (Clark & Paivio, 1991; Sadoski, 2005).

Orthography also provides a non-transient signal to which a child can attend for a longer duration than the transient speech signal (Ricketts et al., 2009). Allowing a child time to process the orthography of a word may improve accuracy and response times when later asked to retrieve that word. Oral speech signals, on the other hand, are only available for the duration of the sound wave and require the child to immediately process the available phonological information. For readers, the presence of orthography may make the phonological information more concrete, resulting in better learning (Clark & Paivio, 1991).

Present Study

Given the evidence of TD children and adults benefitting from the presence of orthographic representations during word learning, the current study aimed to determine if there is evidence in the literature that clinical populations such as DLD or language disorder associated with other diagnoses would also benefit from the presence of orthography during word learning tasks. A recent synthesis on word learning with orthography across all populations demonstrated that there is strong evidence of an orthographic facilitation effect in the areas of phonology and spelling and weaker evidence of an orthographic facilitation effect in the area of semantics (Colenbrander et al., 2019). This synthesis emphasized the need for further research in ecologically valid environments (i.e., classrooms) to determine if orthographic facilitation can occur in large group settings. As SLPs frequently encounter children and adolescents requiring vocabulary intervention in schools, the present study focuses solely on clinical populations.

The following research questions were addressed through this systematic review of the literature:

What clinical populations benefit from the presence of orthographic representations during word learning when compared to an orthography-absent condition?

How can clinicians use the presence of orthography during vocabulary instruction?

Method

Search Strategy

This review was completed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher et al., 2009). The review is registered under PROSPERO (Registration CRD42019123128; https://www.crd.york.ac.uk/prospero /display_record.php?RecordID=123128). To identify relevant studies, Medline via PubMed, CINAHL via EBSCO, ERIC, PsycINFO via Ovid, and SCOPUS databases were searched using search terms found in the attached Supplemental Material. For example, the search terms for the ERIC database included (developmental language disorder OR language impairment OR specific language impairment OR Language Disorders OR SLI OR DLD OR Down syndrome OR Hearing Disorders OR Cochlear Implant OR Cerebral Palsy OR Intellectual Disability OR dyslexia OR autism OR autistic disorder) AND (word learning OR semantics OR vocabulary) AND (orthograph*). The search terms varied based on the individual database's Medical Subject Headings (MeSH) terms. All databases were searched for all of time through December 10, 2019. Published studies (peer-reviewed, presentations, and theses) written in any language were included. To determine if other studies existed outside of the search, selected papers' reference lists were combed for pertinent studies. Reference lists were screened by title to determine if a given study may fit inclusion criteria; if a title indicated it might fit criteria, the article was found, and the abstract screened to determine if it fit the inclusion criteria. In addition, the Web of Science database was used to find articles that had cited the selected papers through a forward search.

Selection Criteria

Studies were included if they fit the inclusion criteria and were group studies, randomized controlled trials, single case experimental design studies, case series, and/or multiple case studies. Inclusion criteria were: 1) participants under age 18, 2) participants belonging to a clinical category (i.e., DLD, ASD, Down syndrome, Dyslexia, Intellectual Disability, hearing impairment, or cerebral palsy), 3) outcomes that include word learning, 4) an experimental or quasi-experimental design, 5) publication in a peer-reviewed journal, and 6) orthography as a manipulated condition. Given the small number of studies identified, an attempt was made to search the grey literature (e.g., find conference presentations); however, no relevant studies were found so the a priori criteria to focus on peer-reviewed published studies was followed. Exclusion criteria were: 1) outcome measures solely targeting reading or spelling ability and 2) adult populations.

Search of the Literature

All studies were pooled into Endnote X9 (Clarivate Analytics, Philadelphia) and duplicates were removed. Studies were then imported into Covidence (Veritas Health Innovation, 2017) and additional duplicates were removed. Next, the titles and abstracts were screened to evaluate if the study met criteria against the inclusion and exclusion criteria. Those chosen for inclusion were then reviewed by the first author through a full-text screening to ensure the study matched the inclusion and exclusion criteria. Both the first author and one additional reviewer, an undergraduate student in Communicative Sciences and Disorders, screened 100% of the titles and abstracts for interrater reliability. The undergraduate student reviewer was trained on the inclusion and exclusion criteria related to this study and guided through a random sample of 20 titles and abstracts to aid in training. Any disagreements were resolved through discussion and consensus with the first author; all disagreements were resolved through discussion with 100% agreement between the first author and the undergraduate student reviewer. In addition, a graduate student reviewer, who was also trained on the inclusion and exclusion criteria, completed a full-text review of 20% of articles selected for full-text review. No disagreements arose.

Quality Assessment

All extracted studies were assessed for quality using a quality assessment tool developed by Sirriyeh et al. (QATSSD; 2012). This tool allows for quality assessment of both qualitative and quantitative studies. The 16-item questionnaire is used to determine the methodological rigor of the study through a 4-point rating scale (0-3 points). Two reviewers, the first author and a post-doctoral fellow, performed the quality assessment for all extracted studies. The reviewers met to discuss what each rating meant and what would be considered an example of each rating level for each item on the questionnaire. The maximum score for either a quantitative or qualitative study was 42 points. *Cohen's Kappa* and inter-rater reliability (IRR), allowing for +/- 1-point difference in scoring, were calculated.

Initial item-by-item interrater reliability revealed a Cohen's *Kappa* of 0.25, a "fair" reliability. When adjacent ratings were considered an agreement- for example, a rating of 2 and 3 were considered an agreement- the average agreement rose to 71.4%. The two reviewers met to form a consensus on any ratings that differed by two or more points and then achieved a Cohen's *Kappa* of 0.64, a "substantial" agreement (Landis & Koch, 1977). In comparison, the authors of the QATSSD reported an inter-rater agreement of 0.68 on four papers piloted during the development of the tool (Sirriyeh et al., 2012).

Data Extraction and Analysis

All selected studies were extracted into a database containing all critical information from the study such as, i) study information, including quality assessment, ii) theoretical underpinnings, iii) participant information, iv) diagnosis information, v) learning procedure, vi) measures, vii) outcomes, viii) limitations, and ix) take away. Categories were reassessed after entering approximately 10% of the data to determine their relevance and adequacy (Pickering & Byrne, 2013). Key results were tabulated and summarized. The graduate student reviewer extracted 20% of the articles for interrater reliability. The first author and graduate student reviewer included the same data and themes in their independent extractions.

Results

Study Selection

A total of 1,110 studies were identified through the databases searched. After removal of duplicates, 880 citations were imported into www.covidence.org. Through title and abstract screening, 853 studies were deemed irrelevant against the inclusion/exclusion criteria. Many of the studies were eliminated due to the participant population being adults with aphasia. Of the remaining 27 studies, 22 were eliminated for the following reasons: 3 wrong outcome measures; 11 wrong intervention; 5 ineligible population; and 3 wrong study design. For example, several studies only measured spelling skills rather than word learning and were thus coded as "wrong outcome measure." Studies that sought to only improve spelling skills rather than vocabulary were coded as "wrong intervention." Studies coded as "ineligible population" included adults or did not include children with disabilities. Studies that were observational in nature, rather than experimental, were coded as "wrong study design." Five studies were extracted for further analysis (see *Figure 1*). No additional studies were found through forward or reverse searches of the selected studies' reference lists.

[Figure 1 approximately here]

Study Characteristics

The total participants across the five selected studies were 263 children and adolescents with the following diagnoses: DLD (n = 27), ASD (n = 47), Dyslexia (n = 128), Dyslexia and co-occurring DLD (n = 44), and Down syndrome (n = 17). In addition, 288 children were used as TD controls for a total of 551 participants. Studies ranged from 41 to 293 participants. Three studies took place in the UK, while two studies included participants from the US. All studies were published in the last seven years. All studies incorporated a within-subjects design whereby participants learned two sets of words- one presented with orthography and one presented without orthography. Table 1 provides in-depth characteristics of each study.

[Table 1 approximately here]

Intervention Approaches

Learning procedures varied across studies, with two studies using a paired-associate learning paradigm (Alt et al., 2019; Baron et al., 2018), one study using categorization (Lucas & Norbury, 2014), and two studies using repetition and production to help children learn words (Mengoni et al., 2013; Ricketts et al., 2015). Both unfamiliar real-world objects related to middle and high school science curriculum (Lucas & Norbury, 2014) and 'alien' nonwords matched to unusual objects or monsters (Alt et al., 2019; Baron et al., 2018; Mengoni et al., 2013; Ricketts et al., 2015) were used as stimuli in studies. All studies used pictures and phonological information to train the words, with half of the items presented with orthographic information. One study (Mengoni et al., 2013) contrasted the orthography with a mix of Greek and Cyrillic script as an added visual cue. The written words were not pointed out and participants were not asked to use the orthography in any way.

Quality Assessment

Each study was assessed for quality using the QATSSD (Sirriyeh et al., 2012) which requires raters to score 16 items on a 0- to 3-point scale. Table 2 provides each study's quality score, what items each study scored highly on, and what items each study scored poorly on.

[Table 2 approximately here]

Synthesis of Measures Reported

Picture Naming. All five studies included a measure of picture naming either as a dichotomous variable (correct/incorrect) or as percent of consonants correct. All studies except the Alt and colleagues (2019) paper use frequentist repeated measures ANOVA to test the effects of word learning with and without orthographic representations. Alt and colleagues (2019) used a Bayesian repeated-measures ANOVA to allow for interpretation of both null and alternative hypotheses. The selected studies demonstrate that orthographic support improves picture naming consistently across diagnoses. Children with dyslexia, with or without concomitant DLD, benefitted significantly from the presence of orthography during training with moderate to large effect sizes (Bayes factor = 6.361e + 14, Hedge's g = 0.62, Alt et al, 2019; $F(1, 45) = 30.51$, $p < .001$, $\eta_p^2 = .404$, Baron et al., 2018). Additionally, according to the Baron and colleagues (2018) study, children with dyslexia learned the phonology of target nonwords in the orthography present condition in fewer trials than TD peers. Children with autism also consistently benefitted from the presence of orthography when learning new words with moderate-to-large effects ($F(1, 39)= 32.08$, $p<.001$, $\eta_p^2 = .45$, Lucas & Norbury, 2014; $F(1,78) = 70.81$, $p < .001$, $\eta_p^2 = .48$, Ricketts et al., 2015). In fact, for the sample of children with ASD in the Lucas and Norbury (2014) study, they performed better than TD children in the orthography present condition. Children and adolescents with Down syndrome were also found to benefit from orthography as much as TD peers matched for word reading ability ($F(1, 41)=36.70$, $p<.001$, $\eta_p^2 =.47$, Mengoni et al., 2013). An orthographic facilitation effect was also observed for children with DLD with moderate-to-large effects ($F(1,78) = 70.81$, $p < .001$, $\eta_p^2 = .48$, Ricketts et al., 2015).

Spoken Word to Picture Matching. All studies included a spoken word-to-picture matching component as a dependent measure. Three of the five studies showed a significant effect for words taught in the presence of orthography during receptive identification tasks (Bayes factor = 22,827.21, Hedge's g = 0.23, Alt et al., 2019; $F(1, 45) = 4.87$, $p = .032$, $\eta_p^2 = .098$, Baron et al., 2018; $F(1, 39) = 6.33$, $p = .016$, $\eta_p^2 = .14$, Lucas & Norbury, 2014). For children with dyslexia, a small-to-large significant effect was demonstrated for words trained in the presence of orthography for spoken word to picture matching (Alt et al., 2019; Baron et al., 2018). For children with autism, one study (Lucas & Norbury, 2014) found a significant effect of orthography on spoken word to picture matching while another study (no statistics reported, Ricketts et al., 2015) found no significant differences between the orthography-present and the orthography-absent conditions on spoken word to picture matching. Ricketts and colleagues (2015) reported that data for this task was non-normally distributed with performance at or near ceiling for many participants, thus making the detection of any differences difficult. Participants of the Ricketts and colleagues (2015) study were exposed to the stimuli a total of 7 times compared to Lucas and Norbury (2014) participants who were exposed to the stimuli a total of 2 times. Thus, the higher number of exposures in the Ricketts and colleagues (2015) study could have resulted in the ceiling effects observed. For children with Down syndrome and children with DLD, no difference between orthography present and orthography absent conditions were found (no statistics reported, Mengoni et al., 2013; no statistics reported, Ricketts et al., 2015).

Repetition. Mengoni and colleagues (2013) were the only researchers to measure word repetition across orthography conditions for participants with Down syndrome. They found no difference between the orthography present and orthography absent conditions when measuring word repetition accuracy. All scores were near ceiling.

Reaction Time. Ricketts and colleagues (2015) measured reaction time during the spoken word-to-picture matching in a field of four for participants with DLD or ASD. There was no significant difference in the reaction time for words that had been trained in the presence of orthography when compared to words trained without orthography ($F(1, 78) = 3.75$, $p = 0.056$, $\eta_p^2 = .05$).

Spelling or Orthographic Choice. Two studies included a measure to determine if children attended to the orthographic information when it was presented (Lucas & Norbury, 2014; Ricketts et al., 2015). Lucas and Norbury (2014) found a significant main effect of orthography on accuracy during an orthographic choice task with a moderate to large effect size. ($F(1, 39) = 20.27$, p,.001, $\eta_p^2 = .34$). Participants were asked to identify the previously shown target written word from a field of two with a phonologically plausible foil. In the Ricketts and colleagues (2015) study, participants completed a spelling to dictation post-test. There was a significant effect of both group and the presence of orthography, with children with DLD performing significantly less well than TD peers ($F(2,78) = 5.05$, $p < .01$, $\eta_p^2 = .12$) and an overall significant orthographic facilitation effect with a large effect size ($F(1,78) = 243.30$, $p < .001$, $\eta_p^2= .76$). Thus, for children with autism, two studies demonstrated that they do, in fact, attend to the orthographic information when presented and benefit from its presence during the learning phase when later asked to identify the target written word or to spell the word to dictation (Lucas & Norbury, 2014; Ricketts et al., 2015). Children with DLD struggled more with this task than TD peers, but also demonstrated a benefit (Ricketts et al., 2015).

Average Duration of Fixations. The Lucas and Norbury (2014) study was the only to include eye-tracking analyses. On average, TD children spent longer looking at the picture, when the written word was also shown, compared to those with autism although this was not significant ($t(38) = 1.96$, $p = 0.057$). In addition, in the orthography absent condition, children with ASD spent a significantly longer duration looking in the area where the written word had appeared earlier for other orthography present targets ($t(37) = 2.00$, $p = 0.05$; Hedge's $g = 0.63$; Lakens, 2013).

Discussion

What clinical populations benefit from the presence of orthography during word learning when compared to an orthography-absent condition?

Through a systematic search of the literature, five studies were found that analyzed the effect of orthographic support on word learning in clinical populations. Children with DLD (Ricketts et al., 2015), Down syndrome (Mengoni et al., 2013), autism (Lucas & Norbury, 2014; Ricketts et al., 2015), and dyslexia (Alt et al., 2019; Baron et al., 2018) demonstrate a benefit from an orthography-present condition during word learning training, particularly for picture naming post-tests.

Based on this review, there is promise in the use of orthographic representations to improve performance in word learning tasks as measured by picture naming tasks for children and adolescents with a variety of disabilities. The studies have demonstrated the ability to create richer semantic representations through learning paradigms that include orthographic support (Perfetti & Hart, 2002). The review shows that children from a variety of clinical populations are able to take advantage of the dual coding provided by training words with orthography present, and thus providing both a non-spoken mental image, in the form of a photograph, and a spoken and written linguistic code (i.e., the phonology, orthography, and web of semantic input; Clark & Pavio, 1991; Sadoski, 2005). Children may be forming mental graphemic representations (Apel et al., 2013) when presented with a written word, which helps them build stronger semantic, orthographic, and phonological representations. Studies of TD children have demonstrated that the degree of benefit from orthographic support varies with reading ability (Ricketts et al., 2009; Rosenthal & Ehri, 2008). It remains to be addressed if this holds true for children with disorders.

Lucas and Norbury (2014) showed evidence of enhanced phonological learning during the training tasks for children with autism. Overall, children with ASD named more pictures accurately than TD children in the post-test on the first day of learning. Although this was not replicated in the Ricketts and colleagues (2015) study, it is possible that a paradigm with longer, more complex words (4-11 letters in length), such as the Lucas and Norbury (2014) study unveils this strength for children with autism. Because the Lucas and Norbury (2014) study used real words drawn from the science curriculum while the Ricketts and colleagues (2015) study used nonwords which were only four to five letters long with three to four sounds, it is difficult to compare the two studies. As some children with autism are known to have enhanced frequency discrimination for pure tones (Jones et al., 2009), phonological skills may be an area of strength for a subset of children with autism, as suggested by Lucas and Norbury (2014).

For spoken word-to-picture matching, orthographic facilitation was observed in three of the five studies. However, even for studies that showed an effect, effect sizes were small as most children performed at ceiling on this receptive test of word knowledge. For example, in the Lucas and Norbury (2014) study, accuracy levels ranged from 62% to 81% after only two exposures to the word in the learning phase. One-third of the participants in the Ricketts and colleagues (2015) study scored at ceiling on the nonword-picture matching posttest, making analyses difficult. Tasks with spoken word-to-picture matching may be susceptible to ceiling effects and thus differences between the orthography present and orthography absent conditions may be more difficult to uncover.

As demonstrated by the Lucas and Norbury (2014) and the Ricketts and colleagues (2015) studies, both children with autism and children with DLD attend to the orthography as evidenced by the improved performance on spelling or orthographic choice tasks for words trained in the presence of orthography. Without explicit instructions to study the orthography, it seems that TD children, children with autism, and children with DLD do attend to the orthographic representations of words. Lucas and Norbury (2014) explicitly explored this using eye-tracking technology. Both children with autism and TD children gazed at the orthography region for similar durations in the orthography present condition. For words that were trained in the absence of orthography, however, children with ASD looked longer at the region where the orthography had been displayed for words in the orthography-present condition.

Surprisingly, the children with dyslexia in the Baron and colleagues (2018) and in the Alt and colleagues (2019) studies showed a benefit for words trained in the presence of orthographic representations during picture naming posttests. Despite having known deficits in grapheme-to-phoneme correspondence, the presence of orthography supported them in learning novel words; however, this effect was less pronounced than with TD children. Baron and colleagues (2018) suggested that children with dyslexia may rely on their stronger orthographic knowledge to bootstrap learning of novel words despite phonological skill deficits. For example, Siegel and colleagues (1995) had TD and dyslexic children complete an orthographic awareness test whereby the children needed to decide which word in a pair could be a word (e.g., *filv* versus *filk*). Children with dyslexia outperformed TD children on this task across a range of reading levels but struggled significantly more than TD children on a pseudoword decoding task. The authors concluded that children with dyslexia may rely on a visual strategy when reading and thus, have superior visual memory skills than TD children. However, a disconnect exists between this strong visual memory and the phonology to which it corresponds, resulting in difficulties translating orthographic knowledge to phonological knowledge.

How can clinicians use the presence of orthography during vocabulary instruction?

Many students on the SLPs' caseload will have difficulty with depth and breadth of vocabulary knowledge (McGregor et al., 2013). It is imperative that SLPs have more tools in their toolbox to improve vocabulary skills for children with communication disorders. The selected studies demonstrate that within an *experimental* environment, children from clinical populations can learn novel vocabulary more quickly and accurately when the orthographic representation is present during learning. It remains to be empirically determined if orthographic support can benefit children with communication disorders in group settings or in more natural environments (as opposed to computer-based vocabulary learning tasks).

Clinicians can include orthographic representations during vocabulary instruction to improve the retention of new vocabulary items. Many possible strategies exist for adding the written word to vocabulary learning tasks. Presenting a word orally, pictorially, and simultaneously presenting the written form may support vocabulary performance in children and adolescents at-risk. In curriculum-based intervention, direct instruction of upcoming key curriculum vocabulary terms can be previewed with students from clinical populations to help them build understanding before being required to use the vocabulary in classroom lessons and readings (e.g., Vadasy et al., 2015). Storybook reading with key words highlighted in bold, red, slightly larger font has been shown to help young TD children acquire initial mental graphemic representations (Apel et al., 2013). It is possible that a similar format may also help children and adolescents from clinical populations derive more meaning from the highlighted key words. For example, Fleury and colleagues (2021) discuss how intentionally drawing attention to key vocabulary during shared storybook reading can help children with ASD learn the meaning of words. Teaching vocabulary words with a picture, a student-friendly definition, gestures, several contextualized examples, and the written word present could also be used in a response-to-intervention (RTI) framework for any child identified as at-risk by general education teachers (e.g., Loftus & Coyne, 2013). Additionally, SLPs could encourage general education teachers to use the presence of written words during in-class vocabulary instruction through in-service presentations and/or consultation with teachers. General education teachers and SLPs could create word walls, not just of target decoding and spelling words, but also of key vocabulary terms, which teachers could refer to throughout their lessons (Harmon et al., 2009).

For those that use augmentative and alternative communication (AAC), frequently a symbol together with the written word are displayed on communication boards or dynamic display devices. Because children who use AAC are taught words with the orthographic representation present, they may be making semantic-orthographic-phonological links without explicit instruction. As the child becomes more familiar with the board or device, the SLP could use a written word-picture matching activity to understand if the child recognizes the written words that are used most frequently with the device. If the child responds well to decoding meaning from written representations, a transition towards the use of an AAC system that most people understand (orthography) might be possible. Additionally, transition to literacy (T2L) technologies are being developed that enlarge the orthography to bring attention to the written form of a selected word to support literacy learning for AAC users (Light et al., 2019).

Limitations

Despite thorough searching of five databases and forward/reverse citation searches, only five studies were found that study the effect of orthography on word learning in clinical populations. Furthermore, all studies were performed in the US or the UK with English-speaking participants. Future research that includes languages with shallow versus deep orthography may shed more light onto how orthography can best facilitate word learning. In addition, bias can exist in the published literature resulting in few studies being published with null or negative findings. It is possible that other studies, as of yet unpublished, have found null or negative results when training novel words in the presence of orthography. Finally, the quality assessment had low rates of interrater reliability; however, these rates of agreement on the questionnaire were close to the original study’s rates of agreement (Sirriyeh et al., 2012).

Future Directions

Although two studies included children with autism, these studies did not include minimally verbal children with autism, neglecting to investigate the full heterogeneity of the autism spectrum. There is a great need for studies exploring the benefit of orthography for minimally verbal school-aged children with autism. If an orthographic facilitation effect is evident for children with dyslexia (Alt et al., 2019; Baron et al., 2018), verbal autism (Lucas & Norbury, 2014; Ricketts et al., 2015), DLD (Ricketts et al., 2015), and Down syndrome (Mengoni et al., 2013), minimally verbal school-aged children with autism could possibly also benefit. As there exists a subset of minimally verbal children with autism with spelling abilities that far exceed their comprehension abilities- a form of hyperlexia- this population may show an orthographic facilitation effect during word learning tasks (Newman et al., 2007). Individuals who have never spoken can process orthography as demonstrated by the nonword spelling abilities of some congenitally anarthric children (Bishop & Robson, 1989a, 1989b). It is possible that those with hyperlexia may be able to harness their fluent word reading abilities to strengthen their semantic learning.

Additionally, future studies should investigate whether children with autism have a particular strength in harnessing root word knowledge or show an advantage when longer words are used. For all groups of children with communication disorders, it would be interesting to analyze the benefit of orthography along a range of reading abilities to determine how reading skills influence learning in the orthography-present condition.

Further research is also needed to determine if the presence of orthographic support will improve vocabulary learning for individuals from other clinical categories, such as those with cerebral palsy, intellectual disability, or hearing loss.

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Figure 1: PRISMA 2009 Flow Diagram

Figure

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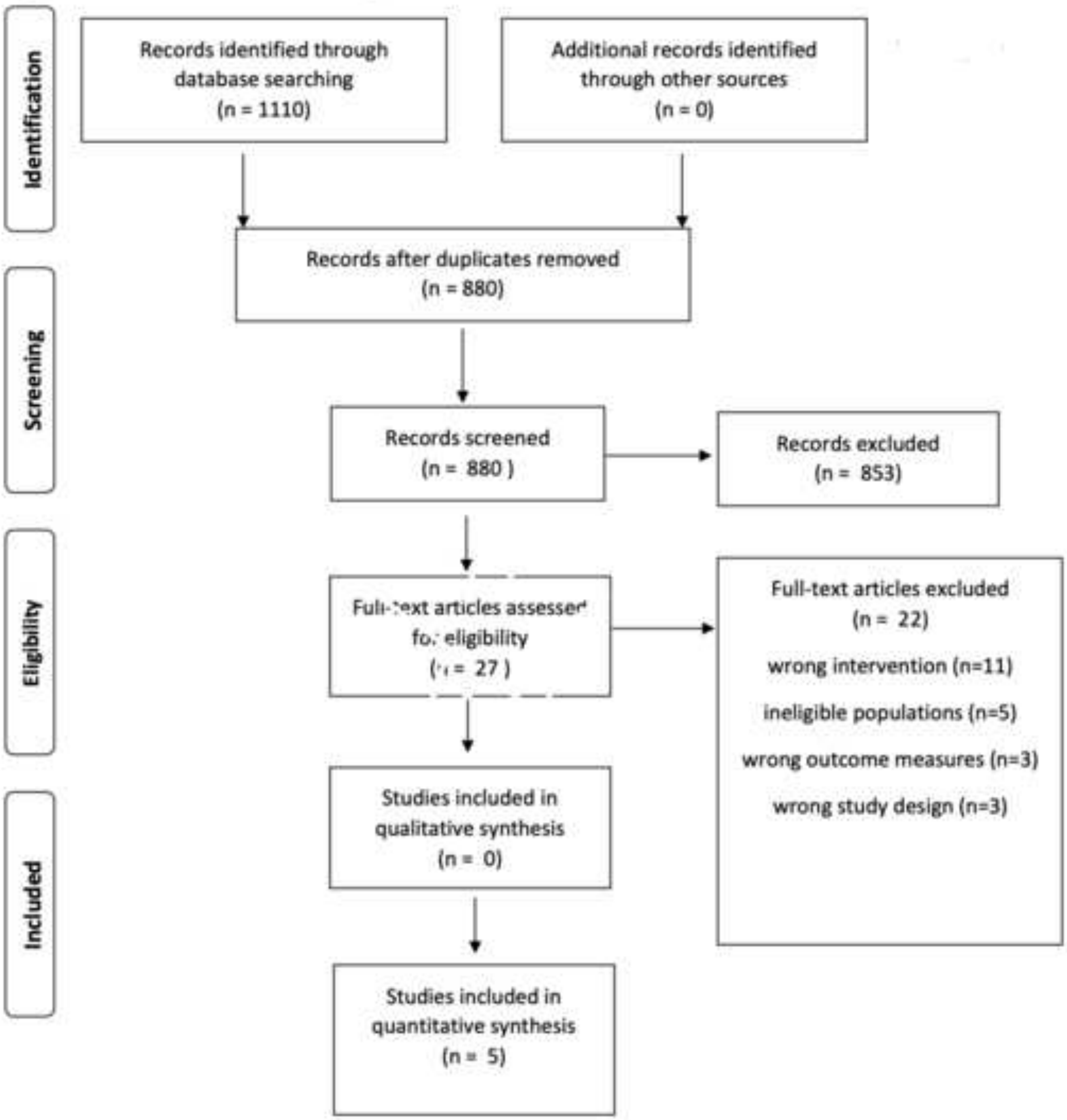

Table 1

Characteristics of Each Included Study

Study	N	Location	Age (mean in years)	Number of Words and Type	Learning Procedures	Condition Results
Alt et al. (2019)	167 TD; 82 Dyslexia; 44 Dyslexia + DLD	USA	7.82	4 CVCCVC nonwords	-Paired associate learning paradigm -Child self-discovers links between phonology and picture -47 total exposures for each word	-Naming task (*g* = 0.62) -Spoken word to picture matching (*g* = 0.23)
Baron et al. (2018)	46 TD; 46 Dyslexia	USA	7.66	4 CVCCVC nonwords	-Paired associate learning paradigm	-Naming task (η_p^2 = .404)

Study	N	Location	Age (mean in years)	Number of Words and Type	Learning Procedures	Condition Results
					-Child self-discovers links between phonology and picture -Receive coins for correct answer; nothing for incorrect answers -17 total exposures for each word	-Spoken word to picture matching (η_p^2 = .098)
Lucas & Norbury (2014)	21 TD; 20 ASD	UK	10.52	16 science curriculum	-Listened to words and then categorized them	-Naming task (η_p^2 = .45)

Study	N	Location	Age (mean in years)	Number of Words and Type	Learning Procedures	Condition Results
				words for ages 11-16	-Feedback on accuracy of categorization -2 total exposures in the learning phase for each word	-Spoken word to picture matching (η_p^2 = .14) -Orthographic choice (η_p^2 = .34)
Mengoni et al. (2013)	27 TD; 17 DS	UK	DS 12.75 TD 6.33	10 CVC nonwords	-4-part learning procedures requiring the child to 1) repeat each word, 2) produce the s and last phoneme of each	-Production trials (η_p^2 = .36) -Naming post-test (η_p^2 = .47)

Study	N	Location	Age (mean in years)	Number of Words and Type	Learning Procedures	Condition Results
					word, 3) identify the word from an increasing field size, and 4) picture naming -Corrective feedback given throughout learning procedures -60 total exposures to each word in the orthography present condition;	

Study	N	Location	Age (mean in years)	Number of Words and Type	Learning Procedures	Condition Results
					120 total exposures to each word in the orthography absent condition to equate stimulus exposure	
Ricketts et al. (2015)	27 TD; 27 DLD; 27 ASD	UK	11.31	12 CVC, CVVC, and CVCC nonwords	-Learning procedures consisted on 1) familiarizing the child with each word, 2) repeating each word, and 3)	-Production trials (η_p^2 = .48) -Spelling (η_p^2 = .76)

Study	N	Location	Age (mean in years)	Number of Words and Type	Learning Procedures	Condition Results
					producing each word -7 total exposures to each word	

Note. Abbreviations: TD= typically developing, DLD= Developmental language disorder, SLI= specific language impairment, ASD= autism spectrum disorder, DS= Down syndrome, C= consonant, V=vowel

Table 2

Quality Assessment Scores for Included Studies

Study	Quality Score	Well rated study characteristics (3 points)	Poorly rated study characteristics (0 points)
Alt et al. (2019)	25.5/42	-Representative sample -Clear description of study procedures -Clear connection between research aims and method of data collection -Clear connection between research aims and data analysis	-Inadequate description of recruitment and attrition -Inadequate measures of reliability and validity -No evidence of user involvement in study design
Baron et al. (2018)	22.5/42	-Explicit theoretical framework -Representative sample -Clear description of study procedures -Clear connection between research aims and data analysis -Strengths and limitations clearly discussed	-No justification for sample size -Inadequate description of recruitment and attrition -Inadequate measures of reliability or validity -No evidence of user involvement in study design
Lucas & Norbury (2014)	19/42	-Clear statement of aims -Clear description of study procedures	-Inadequate description of research setting

Study	Quality Score	Well rated study characteristics (3 points)	Poorly rated study characteristics (0 points)
		-Clear connection between research aims and method of data collection -Clear connection between research aims and data analysis	-No justification for sample size -No measures of reliability or validity -No justification of statistical analyses
Mengoni et al. (2013)	18.5/42	-Clear description of study procedures -Clear connection between research aims and method of analysis	-No justification for sample size -No measures of reliability or validity -No justification for statistical analyses -No evidence of user involvement in study design
Ricketts et al. (2015)	22.5/42	-Clear statement of aims -Clear description of study procedures -Clear connection between research aims and method of analysis	-No justification for sample size -No measures of reliability or validity