Orthographic knowledge and clue-word facilitated spelling in children with Developmental Language Disorder

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Abstract

Purpose: The study investigated the orthographic knowledge and how orthographic and phonological information could support children with Developmental Language Disorder (DLD) to make more accurate spelling attempts.

Method: Children with DLD (N = 37) were matched with chronological age matched children (CAM) and language age matched children (LAM). These children completed specific and general orthographic knowledge tasks as well as spelling task conditions with either no clue word (pre-test), a phonological clue word, or an orthographic clue word.

Results: Children with DLD were significantly less accurate in their specific orthographic knowledge, compared with CAM children, but had similar scores for general orthographic knowledge to CAM children. DLD and both controls had significantly higher spelling scores in the orthographic clue word condition compared with a pre-test pseudo-word spelling task.

Conclusions: Children with DLD acquire the general knowledge of a written language's orthography but, possibly through less print exposure, have less well represented word-specific orthographic knowledge. Moreover, children with DLD are able to extract the orthographic features of a clue word and employ these to produce more accurate spellings. These findings offer support for a spelling intervention approach based on orthography.

Keywords: Developmental Language Disorder, Spelling, Orthographic knowledge, clue-word

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Introduction

Developmental language disorder (DLD) is characterised by prevalent difficulties in one or multiple areas of language which cannot be attributed to a differentiating condition such as hearing impairment or autism (Bishop et al., 2017). A recent meta-analysis of spelling performance in children with DLD suggests that whilst phonological difficulties, such as speech sound errors, can significantly contribute to differences in spelling scores between children with DLD and age-matched children without DLD, nonphonological skills, such as visual letter recognition, likely play a differential role in spelling development (Joye et al., 2019). There is significant heterogeneity of spelling performance in DLD, and the types of errors made seem to be distinct from those made by younger children with equivalent language or spelling abilities (Joye et al., 2019). Children with DLD have been shown to have difficulties with morphological and phonological aspects of spelling development (Critten et al., 2014; Larkin et al., 2013). However, we know very little about how effectively children with DLD can use the spelling conventions of a written language (orthography) when attempting to spell unfamiliar words. Therefore, a critical theoretical and practical step is to establish whether children with DLD have an awareness of orthography that is comparable to age matched or language matched control children, as this will have implications for their spelling instruction.

In the context of the study reported here, phonological skills refer to those involved in the use of a language's speech sound information (Hatcher et al.,1994) and orthographic skills refer to a speller's use of the spelling conventions of a written language (Conrad et al., 2013).

Theoretical models of children's spelling development (e.g., Ehri, 1992; Ehri, 2005) highlight that spelling skills progress in phases, moving from spelling by relying on the visual form of the word to mapping learnt phonemes to graphemes. This phoneme to grapheme phase allows children to make plausible spelling attempts by relying on knowledge drawn from early reading and – where introduced in the classroom – phonics instruction (Castles et al., 2018; Rose, 2006). Children begin to employ their knowledge of a written language's orthography in the final phase of spelling development, the consolidated alphabetic phase (Ehri, 2017). These phases overlap in that a child might rely on the knowledge they developed in an earlier phase, depending on the nature of the spelling task that they are asked to complete (Ehri, 2005).

Although a feature of skilled spelling, research has demonstrated that typically developing children can capitalise on orthographic knowledge from the earliest stages of spelling development (Martinet et al., 2003). Specifically, studies have demonstrated that when shown a 'clue-word' with a particular spelling (e.g. leaf), children can make orthographic analogies to attempt to spell unfamiliar pseudo-words (e.g. meaf, seaf) (Goswami, 1988). Without explicit instruction, children as young as six years old have been shown to employ analogy strategies effectively (Nation & Hulme, 1996). Even without the presence of a clue-word, studies have shown that children make analogies between known spellings when attempting to spell unfamiliar pseudo-words (Bosse et al.,2003; Martinet et al., 2003).

Researchers have identified two types of orthographic knowledge that children use in the spelling attempts: general and specific (Conrad et al., 2013; Rothe et al., 2015). These map to the sublexical and lexical pathways, respectively, in Folk and Rapp's (2015) dual-route model of spelling. General (sublexical) orthographic knowledge refers to information of acceptable letter patterns and combinations in a written language, while word specific (lexical) knowledge refers

to representations stored in the mental lexicon of how individual words are spelled (Conrad et al., 2013). Typically developing children as young as six years old have implicit knowledge about acceptable orthographic sequences in English (e.g. Cassar & Treiman, 1997). Moreover, studies have shown that print exposure is associated with orthographic knowledge acquisition (Stanovich & West, 1989; de Jong & Share, 2007). As children's reading skills progress, orthographic sequences stored in the lexicon expand and provide greater opportunities for spelling unfamiliar words using an analogy strategy (Ehri, 2014).

Research has also shown that children with DLD often have difficulty with reading (e.g., Catts et al., 2002; Dockrell et al., 2009; Vandewalle et al., 2012; Williams et al., 2013) and that reading, more than language difficulties, is associated with spelling difficulties (McCarthy et al., 2012). Moreover, children with DLD often make orthographic spelling errors in written text that are likely to be affected by poor reading skills (Mackie et al., 2013). Moreover, Joye et al. (2019) found, in their meta-analysis, that studies that examine children with DLD who do not have a reading impairment showed that these children had poorer spelling performance on word dictation tasks compared with chronologically age-matched peers.

It is also possible that vocabulary development underpins spelling difficulties in children with DLD. Goffman and Leonard (2000) found that young children with language difficulties had diversity in their spoken vocabulary that was below chronologically age matched children but often above typically developing children matched for mean length utterance. They also demonstrated, in the second year of their intervention study, that spoken lexical diversity often reached the levels spoken by chronologically age matched peers. This level was attained even though many of the children with language difficulties in the study continued to make morphological omissions in their speech (see also Owen & Leonard, 2002). Coloma et al. (2020)

found vocabulary remained lower than typically developing peers in a transparent orthography and continued to contribute to reading comprehension in children, in late primary school, when the association was no longer significant for typical peers. However, the association between vocabulary and reading has not always been found in children with language difficulties (Botting et al., 2006).

The broad language and literacy difficulties seen in DLD might be explained in relation to a range of deficits; in the case of poor word learning, for example, in processing capacity, decoding, memory, or attention (Jackson et al., 2019). Limitations in any one of these areas acts as a risk factor for atypical spelling development; perhaps through more effortful and error-prone attempts to consolidate letter sequences in the lexicon through print exposure, in turn reducing the opportunities for successful practice and use of effective spelling strategies.

Previous research has predominantly focused on phonological and morphological spelling skills in DLD, with additional studies addressing prose writing skills (e.g., Connelly et al., 2012; Williams et al., 2013). Although the majority of studies provide evidence that children with DLD are at risk of spelling impairments (e.g. Bishop & Clarkson, 2003), there are mixed results on the extent of these spelling difficulties (Larkin et al., 2013). Moreover, it is unclear whether these differences are evidence that children with DLD have a specific deficit in spelling ability or have spelling delay comparable to younger, typically developing children (Larkin et al., 2013). The findings of previous studies suggest that individual differences in orthographic knowledge might contribute to the variation in spelling errors found in children with DLD.

Very few studies to date have focused on orthographic spelling skills in children with DLD. Cordewener et al. (2012) investigated early spelling skills and grapheme knowledge in children with DLD. They found significant delays in grapheme knowledge but argued that the

spelling patterns were similar to that of typically developing children. Larkin et al., (2013) also found that children with DLD produced orthographically legal spellings that were consistent with controls groups, however, there was considerable heterogeneity in the spelling performance between children in the group with DLD.

The theoretical basis that would explain spelling difficulties in DLD is not well understood. In typically developing children, spelling development progresses in stages (Frith, 1985, Ehri, 1997; c.f. Apel et al., 2004). These stages are driven by the knowledge children acquire in language, phonology, direct instruction, exposure to print, and feedback from their attempted spellings. In the earliest stage, children spell common words based on the visual patterns they remember. However, as children develop an understanding of phonology, they draw on this to inform their spellings; even in cases where the written form of the word does not conform to phonetic translation. However, these joint visual and phonological representations are necessary as a starting point so that they can be re-represented with orthographic knowledge in the final spelling development stage. Exposure to print – especially irregular words – direct instruction, and feedback facilitates children's employment of orthographic information in their spellings in addition to drawing on existing phonological information. This, orthographic, stage allows typical children to produce accurate, canonical spellings of a words. In English, in contrast to many languages, this stage has significant salience as the written form is orthographically opaque.

Successful integration of phonological and orthographic information seen in the later stages of typical spelling development might not occur in children with DLD. It is possible that this integration is disrupted in children with DLD because of perceptual and/or working memory difficulties. The surface hypothesis (Leonard, 1989, Leonard et al., 1992) argues that children

with DLD have difficulty perceiving speech sounds that have low phonetic salience, such as consonants. This leads to poorer quality representations of the full range of phonological information necessary for spelling at the phoneme to grapheme phase. A complementary theory is that children with DLD have poor working memory, specifically with regard to the phonological loop (Lum et al., 2012, Montgomery, 2003). In the context of spelling, difficulties in storing phonological information result in poorer representations of phonological information in long term memory and less capacity to process phonological information in activities that require the complex management of phonological memory resources, such as phoneme to grapheme translation processes in spelling. This theory is supported by findings of poor phonological memory performance in children with DLD (Larkin & Snowling, 2008).

However, spelling errors in DLD are widespread and not only limited to the phonological or morphological aspects of spelling (Larkin et al., 2013; Critten et al., 2014). A route from phonological impairment to orthographic impairment can be seen in the double deficit hypothesis – often discussed in the context of dyslexia – where children with the severest spelling and reading difficulties have a deficit in both their accuracy of phonological representations and the rate at which they are able to process lexical information (Bowers & Wolf, 1993). Orthographic knowledge acquisition is a route to more accurate spelling in that it is a driver for a child to fully understanding the non-phonological aspects of spelling, such as that “knife” begins with a “k” (Conrad et al., 2012).

There is overwhelming evidence of the value in using a phonics-based approach to early literacy instruction (Hatcher et al., 1994; c.f. Bowers, 2020), yet there is still significant concern over the number of children in the UK with poor reading, writing and spelling skills. Currently, no research study has used a chronological age-matched and language-level matched design to

assess whether children with DLD can use analogy-based spelling strategies. Although there is some evidence that children with DLD are impaired at producing orthographically correct spellings (Mackie & Dockrell, 2004), we need to know whether children with DLD are able to use orthographic analogies as a spelling strategy to the same extent as chronological age-matched or language-matched controls. If children with DLD are impaired at making use of orthographic analogies when spelling, relative to the age-matched control group, this will suggest an additional literacy related deficit in this group that will need direct attention in literacy teaching. A deficit in orthographic spelling skills in comparison to a language-level matched control group highlights a significant area of weakness that goes beyond spoken language level difficulties and is in need of careful scrutiny.

Research Questions

The study seeks to address a number of specific research questions where children with DLD are compared to CAM and LAM control groups:

1. Are children with DLD less accurate when making judgements about words which involve general orthographic information compared with judgements involving specific orthographic information?
2. Are children with DLD slower to make judgements about words which involve general orthographic information compared with judgements involving specific orthographic information?
3. To what extent do children with DLD have poorer single word, and pseudo-word, spelling accuracy?

4. To what extent does the spelling accuracy of children with DLD change when these children are provided with a phonological clue word compared with an orthographic clue word?

Method

Participants

The data in the present study was from 111 participants between the ages of 5 and 11 years. The core language subtests of the CELF 5 (Wiig et al., 2013) were administered to all participants. Children who performed 1 *SD* below the mean on at least two subtests formed the DLD group (N= 37, 9 females, 28 males, mean age 101.27 months, *SD* = 18.85 months, age range = 66 months to 134 months). One standard deviation criterion was in line with the CELF-5 manual's language severity cut-off (c.f. Nitido & Plante, 2020). The children in the DLD group had also either received a diagnosis of DLD, were attending special educational settings for children with speech, language, and communication needs, or had been identified as having language needs within a mainstream setting. Exclusionary factors were a diagnosis of autism or a diagnosis of language impairments primarily associated with another condition such as a genetic syndrome or hearing loss.

Each DLD participant was matched to a child of a similar chronological age (Chronological Age Match; CAM; 9 females, 28 males, *mean* age 102.24 months, *SD* = 19.24 months, age *range* = 65 months to 135 months) and a child who had a similar language age (Language Age Match; LAM; 18 females, 19 males, *mean* age 74.27 months, *SD* = 12.18 months, age *range* = 60 months to 100 months), as measured by the Formulated Sentences raw score on the CELF 5 (Wiig et al., 2013). The Formulated Sentences, an expressive language task,

was chosen to match the DLD to the language level control children as spelling is a form of expressive language skill. The formulated sentences task taps both semantic knowledge and grammatical ability and provides a match across more than one aspect of language while still administering a single subtest, previous studies have also used this measure (e.g. Connelly et al., 2012).

The value of the age- and language- matched design is that differences in the performance of children with DLD relative to peers of the same chronological age can be compared to younger children who may not have yet progressed through all the stages of spelling development. Comparisons between the children with DLD and their LAM peers in terms of spelling accuracy provide some indication of whether the performance of children with DLD can be explained by immature phonological and orthographic systems or whether there seem to be significant deviations from the patterns seen in typical development. Matched designs have often been used to investigate delay or deficit in development (e.g. Bradley & Bryant, 1978; Connelly et al., 2012; Critten et al., 2014; Larkin et al., 2013; Mackie & Dockrell, 2004; Williams et al., 2013).

Materials

Experimental spelling tasks

Orthographic knowledge

Two measures of orthographic knowledge were used. Both were drawn from Conrad et al., (2013) and the tasks were written in OpenSesame (Mathôt et al., 2012). The word specific orthographic knowledge task measured the extent to which children had knowledge of the orthographic information in specific words (Rothe et al., 2015). Meanwhile, the general orthographic knowledge task measured a child's general understanding of the orthography of

written English. Participants responded to trials within both tasks using the 'z' and '/' keys, covered over with smiley-face stickers; these keys corresponded to the position of items on the screen. In line with the procedure and materials devised by (Conrad et al., 2013), for the specific orthographic knowledge task, participants were first provided with a spoken sentence containing the target word, for context. Participants were then asked to decide which, of two items on the left– and right– sides of the screen, was spelled correctly. In each trial, one item was a real word (e.g. "ghost") and the other was a pseudo-word that contained similar orthographic features to the real word (e.g. "goast"). In the general orthographic knowledge task, participants were asked to identify which, of two pseudo-words that were homophones of each other (e.g. "zame" / "zaym"), more closely resembled a real word in English. Conrad et al. (2013) used letter pattern frequency and canonical pronunciation information to build their word lists. The general orthographic task real words (N = 18) had the following lexical properties: *mean* word length = 5.76 (SD = 1.30), *mean* word frequency (zipf value, van Heuven, et al., 2014) = 4.60 (SD = 0.71), mean age of acquisition (Balota et al., 2007) of 5.6 years of age (SD = 1.18), *mean* phonological neighbours (Balota et al., 2007) = 5.82 (SD = 10.49), *mean* orthographic neighbours (Balota et al., 2007) = 2.06 (SD = 3.27). The dependent variables for both the specific and general orthographic knowledge tasks were reaction time and accuracy. Trials within each task were presented randomly.

Experimental Spelling Task

The experimental spelling task had three parts, all of which required the participants to make hand-written spelling attempts with pencil and paper. The items were based on Folk & Rapp's (2004) spelling stimuli. In the first part, children completed a pre-test pseudo-word spelling task and single word spelling task. The pseudo-words and single words were the target

and clue words, respectively, in the subsequent conditions and were presented to participants verbally, in isolation. The order of presentation of the conditions in the remaining two sessions was counterbalanced across participants. In the phonological clue word condition, a clue word, for example “have”, which was phonologically related the target pseudo-word (/tæv/, target spelling: tave), was presented as speech before the target pseudo-word, which was also presented as speech. The clue word and target pseudo-word pairs in this condition shared the same vowel sounds as well as sharing orthography, in this case the letter pattern ‘ave’. Participants were instructed to try to spell the second word they heard, and that the first word might help them to do so. The phonological clue word, followed by the target word, was repeated if the participant requested this; if they had not heard the words or if there had been a distraction during the first presentation of the stimuli.

In the orthographic clue word condition, a clue word, for example, “save”, which was orthographically related to the target pseudo-word, was presented visually on a computer screen before the target pseudo-word (/tæv/, target spelling: tave) was presented as speech. The clue word and target pseudo-word pairs in this condition shared only orthography, i.e. whilst the graphemes ‘ave’ feature in both the clue and target, the vowel sounds differ (/eɪ/ vs. /æ/). Participants were instructed to try to spell the item they heard, and that the word on the screen might help them to do so. The orthographic clue word remained on-screen until the participant had finished spelling the target item.

The single word spelling task consisted of the words ($N = 28$) bead, clown, couch, cough, cove, dead, deaf, five, flown, fork, give, have, leaf, love, mint, mouth, near, north, paid, pint, said, save, tear, touch, tough, work, worth, and youth. That had the following lexical properties: mean word length = 4.36 ($SD = 0.49$), mean word frequency (zipf value, van Heuven et al.,

2014) = 4.73 (*SD* = 0.95), mean age of acquisition (Balota et al., 2007) = 5.3 (*SD* = 1.5), mean phonological neighbours (Balota et al., 2007) = 15.2 (*SD* = 9.5), and mean orthographic neighbours (Balota et al., 2007) = 8.0 (*SD* = 4.0).

The words used for the phonological clue words (cough, dead, deaf, flown, give, have, love, pint, said, tear, touch, work, worth, youth) and the orthographic clue words (bead, clown, couch, cove, five, fork, leaf, mint, mouth, near, north, paid, save, tough) had similar word length, (phonological clue word *mean* = 4.36, *SD* = 0.50, orthographic clue word *mean* = 4.36, *SD* = 0.50), $t(26) = 0$, $p = 1$, $d' = 0$, word frequency (zipf value, van Heuven et al., 2014), (phonological clue word *mean* = 2.71, *SD* = 0.99, orthographic clue word *mean* = 2.86, *SD* = 2.18), $t(25.25) = -1.69$, $p = 0.10$, $d' = -0.64$, similar age of acquisition (Balota et al., 2007) (phonological clue word *mean* = 5.30, *SD* = 1.55, orthographic clue word *mean* = 5.24, *SD* = 1.59), $t(25.98) = 0.10$, $p = .92$, $d' = -0.04$, phonological neighbours (Balota et al., 2007), (phonological clue word *mean* = 20.29, *SD* = 11.42, orthographic clue word *mean* = 21.71, *SD* = 13.93), $t(25) = 0.30$, $p = .77$, $d' = -0.11$, orthographic neighbours (Balota et al., 2007), (phonological clue word *mean* = 9.64, *SD* = 5.54, orthographic clue word *mean* = 10.5, *SD* = 5.00), $t(25.73) = 0.43$, $p = .67$, $d' = -0.16$. The target items were drawn from (Folk & Rapp, 2004) and the procedure was similar to that of Nation and Hulme (1996).

There were four separate measurements of each spelling attempt: composite spelling, phonological skeleton, orthographic acceptability, and vowel accuracy. Composite Spelling, described in Bourassa and Treiman~~,~~ (2003), is a method that scores the quality of each spelling attempt on a scale of 0 to 10, considering orthographic and phonological features, sample reliability: *ICC* = .87 (based on 25.23% of the sample). Phonological skeleton measures how well a spelling attempt contains plausible phonological information, irrespective of the

orthographic acceptability of the attempt. Each spelling attempt is scored either zero or one depending on whether it meets the criteria defined by Bourassa and Treiman (2003), sample reliability *ICC* = .98 (based on 25.23% of the sample). Orthographic acceptability measures whether the spelling attempt provides sufficient orthographic information to convey the target word or pseudo-word, irrespective of the word's phonological plausibility. This is scored either zero or one, depending on the criteria provided by Bourassa and Treiman (2003), sample reliability *ICC* = .75 (based on 25.23% of sample). Vowel accuracy measures whether the salient vowel in the spelling attempt is correct (words) and plausible (pseudo-words), scored either a zero or one, based on the criteria provided by Folk and Rapp (2004), sample reliability *ICC* = .76 (based on 25.23% of sample).

Procedure

Participants were tested in a one-to-one setting in their schools by trained researchers over three visits. The above measures were split over three separate sessions lasting approximately 45 minutes carried out on separate days. In the first session, participants completed the pre-test pseudo-word spelling task and single word spelling task. In the second and third sessions, the order of the presentation of the measures was counterbalanced so that participants completed either the phonological or orthographic clue word condition of the experimental spelling task, and either the general or specific orthographic knowledge task. Accuracy and reaction times for the general and specific orthographic knowledge tasks were recorded automatically by the software. All spelling attempts from the experimental spelling task were coded for composite spelling, orthographic acceptability, phonological skeleton and vowel accuracy.

Results

Data were analysed with linear mixed effects models using the "lmer" package (Bates et al., 2015). Accuracy scores, and spelling measures with binary scores, were analysed using the binomial logit-link option in the function 'glmer'. Pairwise comparisons were analysed using the "emmeans" package (Lenth, 2019), using a Tukey correction for multiple comparisons, in R (R Core Team, 2019).

Are children with DLD less accurate when making judgements about words which involve general orthographic information compared with judgements involving specific orthographic information?

To assess whether children with DLD have difficulties with orthographic knowledge a linear mixed effects model was used. For accuracy as an outcome variable the linear mixed effects model included group (CAM, DLD, LAM) and condition (general, specific) as a fixed effects interaction with by-participants and by-items random effects intercepts (Table 1 reports the descriptive statistics and Table 2 reports the effect estimates). Technical failure resulted in the loss of one LAM child's general orthographic knowledge data and one LAM child was unable to complete the specific orthographic knowledge task in the time available. The data for 36 LAM children was available for both the general and specific orthographic knowledge tasks.

The children with DLD had a significantly higher accuracy on the general task compared with the specific task, $\beta = 0.65$, $SE = 0.16$, $p = 0.01$. The children with DLD also had significantly lower scores in the specific task compared with the CAM group. However, the children with DLD had similar scores to the CAM group in the general condition and similar scores to the LAM group in both conditions.

[Please insert Table 1 about here]

[Please insert Table 2 about here]

[Please insert Figure 1 about here]

Are children with DLD slower to make judgements about words which involve general orthographic information compared with judgements involving specific orthographic information?

To analyse orthographic knowledge response times as an outcome measure, a linear mixed effects model was built. Group (CAM, DLD, LAM) and condition (general, specific) were added as a fixed effects interaction and by-participant and by-items random intercepts were also added (see Table 3 for group means and standard deviations and Table 4 for all effect estimates). Responses that were correct and between 150ms and 10,502.71ms (2.5 *SD* above the mean) were analysed. This resulted in the removal of 1,624 (31.44%) datapoints, including the data from one DLD child. Children with DLD (see Figure 2) were significantly faster responding to items in the general condition compared to the specific condition, β = -692.63, *SE* = 123.02, $p < .001$. The children with DLD were also significantly slower, compared with the CAM control group, in the specific condition, β = -870.25, *SE* = 304.01, $p = 0.048$. Children with DLD had similar response times to both groups in the general condition and to the LAM group in the specific condition.

[Please insert Table 3 about here]

[Please insert Table 4 about here]

[Please insert Figure 2 about here]

To what extent do children with DLD have poorer single word, and pseudo-word, spelling accuracy?

Single word spelling

To analyse the single word spelling task (see Table 5), four linear mixed effects models were built, one for each of the spelling scores (composite spelling, orthographic acceptability, phonological skeleton, vowel accuracy) as outcome measures. Each had, by-participants and by-items random intercepts and grou*p* as a fixed effect. The children with DLD had significantly lower scores than the CAM group for composite spelling, $\beta = 1.13$, $SE = .24$, $p < .001$, orthographic acceptability, $\beta = 1.72$, $SE = .45$, $p < .001$, for phonological skeleton, $\beta = 2.47$, $SE = .5$, $p < .001$, and for vowel accuracy, $\beta = 2.59$, $SE = 0.51$, $p < .001$. However, the DLD and the LAM groups had similar scores in all four measures. Figure 3 and Table 6 provides a summary of these results.

[Please insert Table 5 about here]

[Please insert Table 6 about here]

[Please insert Figure 3 about here]

Pseudo-word spelling

Using the pre-test pseudo-word spelling task with each of the spelling measures as the outcome measures, by-participants and by-items random intercepts models – with grou*p* as a fixed effect – were carried out. The results are summarised in Figure 4 (see Table 7 for the descriptive statistics and Table 8 for the effect estimates). For composite spelling, the children with DLD had significantly lower scores than the CAM group, $\beta = 0.89$, $SE = .2$, $p < .001$. This was also the case for orthographic acceptability, $\beta = 1.51$, $SE = .59$, $p = .03$, phonological

skeleton, $\beta = 1.27$, $SE = .34$, $p < .001$, and vowel accuracy, $\beta = 0.93$, $SE = .3$, $p = .01$. In comparison to the LAM group, the children with DLD had similar scores for all measures.

[Please insert Table 7 about here]

[Please insert Table 8 about here]

[Please insert Figure 4 about here]

To what extent does the spelling accuracy of children with DLD change when these children are provided with a phonological clue word compared with an orthographic clue word?

For each of the outcome measures, composite spelling, orthographic acceptability, phonological skeleton, and vowel accuracy, a linear mixed effects model was built. Grou*p* (DLD, CAM, LAM) and Condition (pre-test pseudo-word and phonological clue word) were added as a fixed effects interaction and by-participant and by-item random intercepts were added to the model.

Composite Spelling

For composite spelling as an outcome variable (see Table 9 for descriptive statistics and Table 10 for all effect estimates), the children with DLD had significantly higher scores comparing the orthographic clue word condition with the pre-test condition, $\beta = 0.91$, $SE = 0.07$, $p < .001$, and the phonological clue word condition, $\beta = 0.65$, $SE = 0.07$, $p < .001$. Between groups, the children with DLD had significantly lower scores compared to the CAM group in the pre-test condition, $\beta = 0.89$, $SE = 0.21$, $p < .001$, the phonological clue word condition, $\beta = 1.11$, $SE = 0.21$, $p < .001$, and the orthographic clue word condition, $\beta = 0.67$, $SE = 0.21$, $p = 0.04$. The children with DLD had similar scores to the LAM group in all conditions (see Figure 5).

[Please insert Table 9 about here]

[Please insert Table 10 about here]

[Please insert Figure 5 about here]

Orthographic acceptability

For orthographic acceptability as an outcome variable (see Table 11 and Figure 6 for descriptive statistics), several interactions yielded significant differences (see Table 12). However, only one DLD comparison had a significant difference, the group had higher scores in the orthographic clue word condition compared to the pre-test condition, $\beta = 1.01$, $SE = 0.27$, $p = 0.01$.

[Please insert Table 11 about here]

[Please insert Table 12 about here]

[Please insert Figure 6 about here]

Phonological Skeleton

For phonological skeleton as an outcome variable (see Table 13 for descriptive statistics and Table 14 for all effect estimates). Children with DLD (see Figure 7) had significantly higher scores in the orthographic clue word condition compared to the pre-test condition, $\beta = 2.98$, $SE = 0.19$, $p < .001$, and comparing the orthographic clue word condition with the phonological clue word condition, $\beta = 1.86$, $SE = 0.17$, $p < .001$, the group also had significantly higher scores in the phonological clue word condition compared with the pre-test condition, $\beta = 1.11$, $SE = 0.18$, $p < .001$. In comparisons between groups, the children with DLD had significantly lower pre-test scores compared to the CAM group, $\beta = 1.32$, $SE = 0.41$, $p = 0.03$, and significantly lower scores

in the phonological clue word condition compared to the CAM group, $\beta = 1.95$, $SE = 0.40$, $p < .001$, but scores were similar in the orthographic clue word condition. Compared with the LAM group, the children with DLD had similar scores in each condition.

[Please insert Table 13 about here]

[Please insert Table 14 about here]

[Please insert Figure 7 about here]

Vowel Accuracy

For vowel accuracy as the outcome measure (see Table 15 for descriptive statistics and Table 16 for all effect estimates). Children with DLD had significantly higher orthographic clue word scores compared to the pre-test condition, $\beta = 3.44$, $SE = 0.21$, $p < .001$, and significantly higher orthographic clue word scores compared with the phonological condition, $\beta = 2.07$, $SE = 0.17$, $p < .001$. The grou*p* also had significantly higher scores in the phonological condition compared with the pre-test condition, $\beta = 1.36$, $SE = 0.20$, $p < .001$. Compared with the control groups, the children with DLD had similar pre-test condition and orthographic clue word condition scores to the CAM group but the children with DLD had significantly lower scores in the phonological clue-word condition, $\beta = 2.02$, $SE = 0.42$, $p < .001$. Compared with the LAM group, the scores were similar in each condition (see Figure 8).

[Please insert Table 15 about here]

[Please insert Table 16 about here]

[Please insert Figure 8 about here]

Discussion

The study aimed to investigate the orthographic knowledge and spelling accuracy of children with DLD compared with a group matched for chronological age and a group matched for language. Previous studies have demonstrated that children with DLD have difficulties spelling words in comparison to their chronologically age-matched peers. This study contributes original findings to the DLD literacy field in demonstrating the pattern of orthographic knowledge skills and clue-word facilitated spelling attempts in children with DLD, relative to control matched groups. Overall, the findings are in line with previous studies of spelling and children with language disorders (Bishop & Clarkson, 2003; Critten et al., 2014; Cordewener et al., 2012; Larkin et al., 2013) and support those, more broadly, of writing (Williams et al., 2013). The study reported here extends the findings from general spelling (Bishop & Clarkson, 2003), and morphological spelling delay (Critten et al. 2014; Larkin et al. 2013) to orthography as well.

Although children with DLD had similar general orthographic knowledge to the control groups, they were significantly less accurate and had slower response times to controls in the specific knowledge condition. Both general and specific knowledge develop through engagement with text (Stanovich & West, 1989; de Jong & Share, 2007) and can be conceptualized as two routes to spelling a word (Folk & Rapp, 2015). The findings indicate that children with DLD have acquired the general, sublexical, knowledge to a similar level to chronologically age matched peers. A finding supported by the orthographic acceptability scores in the clue-word task, which were near ceiling. This knowledge allows children to make spelling attempts for words using phoneme to grapheme conversion (Folk & Rapp, 2015). However, children with DLD did not demonstrate that they had acquired the specific word-level orthographic knowledge that allows for words in the mental lexicon to the spelt without reliance on the phoneme to

493 grapheme conversion route. As with reading (Coltheart et al. 2001), where the lexical route is
494 faster than the sublexical route and provides a more accurate reading output, the lexical route for
495 spelling allows a writer to access the orthographic knowledge associated with the target word.
496 This provides a more accurate representation of the spelt word and access to semantic
497 knowledge, which is unavailable in the sublexical route (Folk & Rapp, 2015).

498 The children with DLD had patterns of response to specific orthographic knowledge that
499 were similar to the LAM group. The LAM group had general orthographic knowledge accuracy
500 that was similar to the CAM group but specific orthographic knowledge accuracy that was
501 significantly lower, and with slower response times, than the CAM group. One interpretation is
502 that the typically developing LAM children are likely to – through engagement with print –
503 develop specific orthographic knowledge to a similar level to the CAM group as they grow older.
504 However, the children with DLD, even though they have had a similar amount of time to acquire
505 CAM level specific orthographic knowledge, have not been able to do so. This finding is in line
506 with McMurray et al. (2019) who provide evidence that individuals with DLD experience real-
507 time lexical processing deficits including an inability to correctly map input via the suppression
508 of lexical competitors.

509 When measured by composite spelling, phonological skeleton, and vowel accuracy,
510 children's spelling attempts followed a similar pattern with regard to the clue word conditions.
511 The phonological clue word facilitated more accurate spelling, compared with a pre-test without
512 a clue word, and when the orthographic clue word was presented children had the highest scores.
513 Both the DLD and LAM groups had scores similar to each other, while the CAM group had
514 scores often higher than the other two groups.

The spelling attempt findings suggest that in the pre-test condition, without a clue word, LAM children attempted pseudo-word spellings they heard by drawing on early stage (Ehri, 2005), visual and, possibly, phonological knowledge. It is likely that children with DLD relied on the same knowledge since their responses were in line with the LAM group. This pattern is reflected in their lower scores and is in contrast to the CAM group who were often able to form significantly more accurate spelling attempts. Providing a phonologically related real word, as a clue, increased spelling attempt scores but the orthographically related clue word significantly increased spelling scores, compared with the pre-test measure. In the orthographic condition, it is likely that that children were able to extract the orthographically relevant features from the clue word, drawing on visual-orthographic processing skills, and apply this to the target pseudo-word (c.f. de Jong & Share, 2007). The findings in this study are in line with research that has shown that children, even in early stages of spelling, are able to use the information in related words to make accurate spelling attempts (Bosse et al., 2003; Goswami, 1988; Martinet et al., 2003; Nation & Hulme, 1996).

An implication of the surface deficit (Leonard, 1989, Leonard et al., 1992) is that, if children with DLD have difficulties with speech sounds that have low salience they would then have difficulties perceiving the speech sound pattern of the spoken target accurately. This would account for the lower accuracy in spelling attempts relative to the CAM group but not the similarity in accuracy to the LAM group. As the LAM group are typically developing children, they are not expected to have a low saliency speech sound deficit.

The first possibility is that the lower accuracy in the spelling conditions, observed on a behavioral level, arises from two different underlying explanations. In the LAM group it is insufficiently represented phonological and orthographic through lack of print exposure, relative

to the CAM group (c.f. Stanovich & West, 1989). However, in the DLD group the lower accuracy is because of a surface deficit. The second – complementary to the first possibility – is that, although the surface deficit could affect spelling attempts in the clue-word task itself, the deficit primarily operates as a cumulative deficit over a number of years by subtly suppressing a child with DLD's ability to develop fully represented speech sounds in their mental lexicon. This would give rise to behavioral responses similar to a group matched for language age. The third possibility is that the findings are not explained by the surface deficit and another explanation is possible. That the children with DLD are not able to store the spoken target sufficiently well in their phonological loop; a cognitive system that is less well developed in the LAM group compared with the CAM group (Lum et al., 2012, Montgomery, 2003).

Limitations

The study has several limitations when considering the findings. The CAM group were near ceiling in their pre-test spelling ability. Moreover, scores in the orthographic acceptability score were near ceiling for all groups. Therefore, their ability to improve following provision of the clue word would be muted compared with the LAM group and the children with DLD.

It is possible that different durations of exposure, and different modes of presentation of the phonological and orthographic clue words might vary the accuracy of participants' target spelling attempts across conditions over and above the differing priming effects. Given the implications in DLD for the phonological loop hypothesis (Lum et al., 2012, Montgomery, 2003), the shorter duration of clue word exposure in the phonological condition may have affected the ability of participants to maximally benefit from clue word information in this condition. The differences between the conditions, in future studies, might be reduced by limiting the duration of exposure to orthographic clue word, or controlled for by presenting

additional 'filler' items where phonological clues are presented visually; orthographic clues are presented auditorily; and clues unrelated to the target are presented in both modes. In addition, the phonological clue words also shared orthographic cues with the target word, arguably making this a cross-modal condition. Future work would benefit from addressing this confound with clearer differentiation between phonological and orthographic clues.

The study design was not able to directly measure whether spelling errors were associated with vocabulary (Goffman & Leonard, 2000; Coloma et al. 2020; c. f. Botting et al., 2006). However, the clue words typically had low ages of acquisition (around four to five years of age) in order to mitigate the risk that children in any of the three groups were not familiar with these words. Although Folk and Rapp (2015) do not provide lexical information for their specific orthographic word list, their mean age of acquisition is similar to that of the clue words.

Whilst the similarities observed in the findings when comparing the DLD and LAM groups tentatively suggest that psycholinguistic systems underpinning the spelling abilities of children with DLD are immature rather than significantly deviating from typical development, a longitudinal study would be required to establish this.

Future directions

A key finding of this study was that children with DLD possessed general knowledge of orthography, consistent with their CAM peers. Moreover, these children were able to use orthographic clue word information in their subsequent spellings so that their spelling scores were higher. This indicates an avenue for an intervention involving orthographic information for children with DLD, consistent with stage theories of spelling (Ehri, 1992; Ehri, 2005). In order to establish this potential area of strength, educational assessment practice for children with DLD

might look to include specific measurement of orthographic skills alongside wider literacy measures.

Conclusion

The study investigated the orthographic knowledge and the role phonological and orthographic clue words play in spelling attempts for children with DLD. The children with DLD had word specific knowledge that was significantly less accurate than that of CAM controls but was similar to that of LAM controls. However, the children with DLD had general orthographic knowledge in line with the CAM and LAM controls. Moreover, the children with DLD had significantly higher spelling scores when their spelling attempts were facilitated by an orthographic clue word in comparison to a spelling a target word without a clue word. The findings suggest literacy interventions that involve orthographic knowledge could help children with DLD.

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Figure Legends

Figure 1. Group means (CAM, DLD, LAM) comparing accuracy to specific and orthographic knowledge, error bars are the 95% confidence intervals.

Figure 2. Group means (CAM, DLD, LAM) comparing response times to specific and orthographic knowledge, error bars are the 95% confidence intervals.

Figure 3. Group means (CAM, DLD, LAM) comparing spelling measure scores (composite spelling, orthographic acceptability, phonological skeleton, vowel accuracy) to real words, error bars are the 95% confidence intervals.

Figure 4. Group means (CAM, DLD, LAM) comparing spelling measure scores (composite spelling, orthographic acceptability, phonological skeleton, vowel accuracy) to pseudo-words, error bars are the 95% confidence intervals.

Figure 5. Group means for composite spelling by condition (pre-test, phonological clue, orthographic clue) and group (CAM, DLD, LAM). Error bars are the 95% confidence intervals.

Figure 6. Group means for orthographic acceptability by condition (pre-test, phonological clue, orthographic clue) and group (CAM, DLD, LAM), the error bars are the 95% confidence intervals.

Figure 7. Group means for phonological skeleton by condition (pre-test, phonological clue, orthographic clue) and group (CAM, DLD, LAM), error bars are 95% confidence intervals.

Figure 8. Group means for vowel accuracy by condition (pre-test, phonological clue, orthographic clue) and group (CAM, DLD, LAM), error bars are 95% confidence intervals.