Review

The evaluation of word-learning abilities in people with developmental language disorder: a scoping review

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Abstract

Background: The ability to learn new words is critical in the development of oral and written language, and significantly impacts engagement in social, academic and vocational situations. Many studies have evaluated the word-learning process in people with developmental language disorder (DLD). However, methodologies for assessment are heterogeneous, creating difficulties in synthesizing findings and identifying gaps in the knowledge base.

Aims: To scope systematically the literature and identify key methodological parameters considered in evaluations of word learning in people with DLD; and to identify gaps in the literature to guide further research in this area.

Methods & Procedures: Twelve databases were searched and a total of 70 studies that met eligibility criteria were identified. The studies were evaluated according to key parameters that researchers varied in their word-learning methodologies.

Main contribution: Most research has focused on word learning in the oral modality, and specifically in children with DLD. Fewer studies have explored word learning in adults and adolescents with DLD, and in the written modality. Depending on the research question and theoretical perspective driving the investigation, methodologies for assessing word learning considered a range of parameters, including words being learned, learning context and cues to support learning in the tasks.

Conclusions & Implications: This review aggregates a variety of methods used previously to assess word learning. Findings highlight the need for further research to explore areas such as: the learning of varied word types (e.g., adjectives and adverbs); learning in the written modality; and word learning (both oral and written) in adolescents and adults with DLD.

Keywords: word learning, vocabulary, developmental language disorder, assessment, scoping review.

What this paper adds

What is already known on the subject
The ability to acquire new vocabulary is a complex process, and the findings of numerous studies document this as an area of weakness for children with DLD. The range of methods for evaluating word learning reflect the multifaceted nature of this skill. Yet, these varied methodologies used in the literature to evaluate word learning in people with DLD have not been the focus of a previous review.

What this paper adds to existing knowledge
This review involved systematic scoping of the literature to summarize previous methodologies used to evaluate word learning in people (of all ages) with DLD. Despite the complex nature of the word-learning process, it identified that approaches to evaluate word learning are guided by several methodological parameters. These findings are discussed in light of varied theoretical perspectives, and gaps in the knowledge base are identified to guide future research efforts.

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What are the potential or actual clinical implications of this work?
While an abundance of word-learning assessment tasks has been used in research, to our knowledge these types of measures are seldom used in clinical practice by speech and language therapists (SLTs). Future research may focus on translating research to practice so that SLTs are equipped with resources to evaluate the word-learning process in clients with DLD.

Introduction

The skill of acquiring new words is fundamental to language development (Leonard 2014). Word learning commences in early infancy and involves a multifaceted and incremental process (Carey 2010, Nation 2014), which has been conceptualized to involve the gradual mapping of information about the word's form and meaning (Carey 2010). The term *fast mapping* is often used to describe the initial process of word learning in which a tentative map of the phonological and semantic representations is developed after minimal (e.g., one to four) exposures (Chiat 2001, Rice *et al.* 1992). Further encounters with the novel word prompt gradual refinement in long-term memory (i.e., *slow mapping*; Carey 2010), during which form–meaning representations are specified further across contexts.

While children with typically developing (TD) language appear to learn new words with relative ease, this process is problematic for many children, including those with developmental language disorder (DLD). DLD is marked by varied oral language deficits (e.g., in semantic, grammatical and discourse skills; Bishop *et al.* 2016), and a large body of research indicates that many children with DLD experience poor performance when their word-learning skills are compared with those of TD children (e.g., Alt and Spaulding 2011, Gray 2004, Jackson *et al.* 2016, Rice *et al.* 1994, Storkel *et al.* 2017b, van der Lely 1994). Children with DLD struggle with learning both the phonological form of new words and semantic attributes such as colour, shape and pattern (e.g., Alt and Plante 2006), and are also less sensitive to syntactic cues, resulting in difficulty ascertaining novel word information from spoken sentences (Johnson and de Villiers 2009). A meta-analysis by Kan and Windsor (2010) confirmed that children with DLD (termed 'primary language impairment' in the paper) showed significantly poorer word-learning performance than age-matched TD children, but performed equivalently to younger TD children matched for language skills. Recent research also indicates that word-learning deficits may persist into adulthood for people with DLD (McGregor *et al.* 2017a).

While there is a general consensus that this is an area of deficit for most children with DLD, methods for evaluating the word-learning process vary considerably across studies. Word-learning assessment tasks generally involve assigning a non-word (or unusual real word) label to an unfamiliar object (if teaching nouns) or action (if teaching verbs), to control for previous language knowledge (Kan and Windsor 2010). Children are presented with the novel words embedded in spoken sentences in either an interactive activity with the researcher, or on a computer (Alt 2011, Jackson *et al.* 2016). The ability to produce and/or comprehend the target words is then evaluated. For instance, naming tasks are used to evaluate the child's production of the target word (e.g., Dollaghan 1987). Comprehension is tested through tasks requiring the child to select the target item when they hear the novel word (e.g., Rice *et al.* 1994), or to select the correct label of the novel word when presented with a range of choices (including the target and phonologically similar distractors; Alt 2011). If a study also explores how well children learn the semantic features of novel words, knowledge may be tested using a describing or definition task (e.g., Nash and Donaldson 2005, Vogt and Kauschke 2017a). This general task design has been adapted widely to allow examination of different aspects of word learning.

In earlier studies, Rice and colleagues introduced novel object-word pairs using a quick incidental learning (QUIL) paradigm in which new words were embedded in sentences and presented in animated stories, without explicit instruction to attend to the novel words (Oetting *et al.* 1995, Rice *et al.* 1990, 1992, 1994). This design was intended to replicate the incidental nature of everyday word-learning situations, and comprehension of the novel words was tested using a picture identification task. While the QUIL approach has also been used in more recent studies (e.g., Rohlfing *et al.* 2018), other researchers have adopted an instructional paradigm in which the researcher makes explicit the intention of the task and draws attention to novel words in an interactive approach (Nash and Donaldson 2005). For instance, Jackson *et al.* (2016) presented novel objects with non-word labels in simple sentences within an interactive play activity, and measured learning using a naming task.

Word learning has also been evaluated over a series of days. For instance, Gray and colleagues used an extended word-learning paradigm in which novel nouns were taught to preschool children over four days using an interactive play context, with learning evaluated using comprehension and naming tasks (Kiernan and Gray 1998, Gray 2003, 2004, 2005). A similar model was

used by Storkel *et al.* (2017b) using a book sharing task to identify the optimal intensity of exposures to novel words required by preschool children with DLD so that they may perform comparably with TD children.

Different methods have also been employed to explore how well children with DLD learn the form and meaning of novel words when they are presented in a reading task (e.g., Steele and Watkins 2010, Wolter and Apel 2010). Learning the meaning of novel words through reading involves several processes like learning in an oral modality, such as using syntactic cues to build new word knowledge from context (Steele and Watkins 2010). However, learning the novel word form differs, because an orthographic representation, or mental graphemic representation (MGR), must be formed (rather than a phonological representation; Ricketts *et al.* 2015). Yet, MGR development may also involve phonological processes, such as the translation of graphemes in novel words to phonemes and then 'blending' of the phonemes to pronounce the written word (Wolter and Apel 2010).

Purpose and research question

As a wide range of tasks has been used to evaluate word learning in children and adults with DLD, a review of these methodologies was warranted. The nature of this investigation was not amenable to a systematic review, which is suited to answering precise questions, usually on the effectiveness of an intervention (Peters *et al.* 2015). Instead, a scoping review was conducted, as this type of review allows for a broader approach to map the available literature on a topic (Arksey and O'Malley 2005, Peters *et al.* 2015). This review therefore aimed to systematically scope the literature to identify the range of methodologies used to evaluate word learning in people (of any age) with DLD and to identify gaps in previous literature to guide further research (e.g., to identify whether there are aspects of word learning that have not been well investigated). The central question guiding this review was: What methods have been used to evaluate word learning in the first language of people who have developmental language disorder?

Method

This scoping review was guided by the five-stage methodological approach outlined by Levac *et al.* (2010) and the Joanna Briggs Institute and Collaborating Centres (Peters *et al.* 2015): (1) identify the research question (stated above); (2) identify relevant studies; (3) select studies; (4) chart the data; and (5) collate, summarize and report the results.

Identifying relevant studies

Where: identification of peer-reviewed literature

The search terms (listed in the Supplementary materials) were identified based on the aspects of *Population* (people of all ages with DLD) and *Concept* (the evaluation of novel word learning; Peters *et al.* 2015), and were used to search 12 databases. First, the Cochrane Library (Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, and the Central Register of Controlled trials) was searched to identify any previous reviews. A meta-analysis by Kan and Windsor (2010) was identified, which reviewed word-learning *performance* in children with DLD and TD children; however, no meta-analyses, systematic reviews, or scoping reviews on word-learning methodology were found. A search of Ovid (AMED, PsychINFO, and MEDLINE), Web of Science (Current Contents Connect), ProQuest, Scopus, Embase, Informit and Google Scholar electronic databases was also conducted.

Where: other sources

The database searches included both peer-reviewed and grey literature (e.g., unpublished theses and other non-peer reviewed work) at the same time. Only primary studies were included, and commentary papers and reviews were excluded. In addition, reference lists of review papers were hand-searched for any additional articles, and a hand search of a special issue on word learning in the *Journal of Clinical Practice in Speech–Language Pathology* was conducted.

Time span and language

Database searching included any articles published before 2018. Searches were conducted between February and March 2018. There were no articles published prior to 1987 that met eligibility criteria. All retrieved articles were available in English, except for one paper for which a translation could not be obtained (Yang *et al.* 2015).

Study selection

Eligibility criteria to guide the selection of studies were established through team discussions, using the aspects of *Population*, *Concept* and *Context* (Peters *et al.* 2015). The full criteria are listed in the supplementary materials.

Population

The focus of the review was people of all ages with DLD. Studies were included if people in the 'DLD' group were identified according to conventional or

clinical criteria, which was difficult to specify as varied terms were used in the literature (e.g., 'specific language impairment', 'language difficulties' and 'primary language impairment'). Furthermore, varied criteria were used to identify 'DLD'. To capture a broad range of studies, eligibility criteria were guided by those outlined in Kan and Windsor (2010) and the Delphi consensus study (Bishop *et al.* 2016):

- Reference to low receptive and/or expressive oral language skills, as indicated by performance of ≤ 1 SD below the mean on at least one standardized oral language test.
- Reference to evidence of no intellectual disability, as indicated by achieving a standard score of >70 on a standardized measure of nonverbal cognitive ability.

In accordance with the criteria for 'developmental' language disorder, studies that included children with an acquired language disorder were excluded. Adults with an acquired language disorder were also not included, and studies needed to provide evidence of adult participants' language difficulties being developmental in nature. Studies were therefore included if a self-report measure regarding a history of language difficulties was used, plus a confirmatory standardized assessment indicating current language disorder or impairment (e.g., Alt and Gutmann 2009).

People learning novel words in their primary language was the focus. Word learning in a second language is inherently more complex than in a first language; it is impacted by degree of language exposure and may involve different mechanisms for familiar and unfamiliar languages (Thordardottir 2011). The complex nature of bilingual word learning in DLD therefore went beyond the scope of the current review.

Concept

The aim was to examine broadly research that investigated any aspect of word learning, such as learning from an oral or written task and learning the different representations of novel words, for example, phonological, semantic and orthographic. Tasks needed to include some element of learning the word form, either phonological or orthographic. Studies that included only visual learning, for instance, were not included in the review as these were not considered to reflect language learning (e.g., Alt 2013). Studies that measured existing vocabulary (e.g., using a standardized test) as an indication of word-learning capabilities were not included. Instead, studies needed to teach and evaluate the learning of new words.

Context

Studies that evaluated word learning across a range of settings (e.g., research, educational or clinical) were the focus. Only those that measured word learning behaviourally (rather than neurologically, or through cognitive modelling) were included as these investigations were deemed most relevant to practitioners and educators. These criteria were used to guide the procedure for study selection, as described below.

Results

Procedure for study selection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (Peters *et al.* 2015) outlines the search decision process for our review (figure 1). The database searches yielded a total of 1265 reports, and a further five were identified via other sources (e.g., hand-searching pages of key researchers). After the removal of duplicates, there were 369 remaining. Of these, 360 were peer reviewed and nine were grey literature (all unpublished theses).

Thus, 369 records were reviewed. Initially, the first author of this review screened the titles and keywords according to the eligibility criteria. Then, the abstracts of articles that passed the first stage of screening were independently screened for inclusion by the first and second authors. There was high interrater agreement in the reviewers' classification of papers for inclusion, $\kappa = .71$ (95% confidence interval (CI) = .63 to .78), $p < .001$. Contended articles were discussed to reach a consensus. A total of 101 articles met criteria at this stage.

The same authors then independently reviewed these 101 articles at the full-text level with high agreement, $\kappa = .80$, (95% CI = .67 to .92), $p < .001$. After discussion of contended articles, 63 articles were included and 38 were excluded: 19 studies were excluded as they did not evaluate the process of word learning (e.g., only a static assessment of word knowledge/vocabulary was included); two were theses that were later published as peer-reviewed articles (which were included in the review); six involved teaching novel words in a language that was not the participants' primary language; five did not include a 'DLD' group; and six did not apply appropriate criteria for inclusion in the 'DLD' group (e.g., children were 'late talkers' but did not meet DLD criteria). Following full-text screening, seven additional articles were further identified (and met criteria) through hand-searching reference lists, yielding a total of 70 articles.

A total of 47 studies were conducted in the United States, eight in the UK, four in Germany, three in Canada, three in the Netherlands, two in Israel, and one
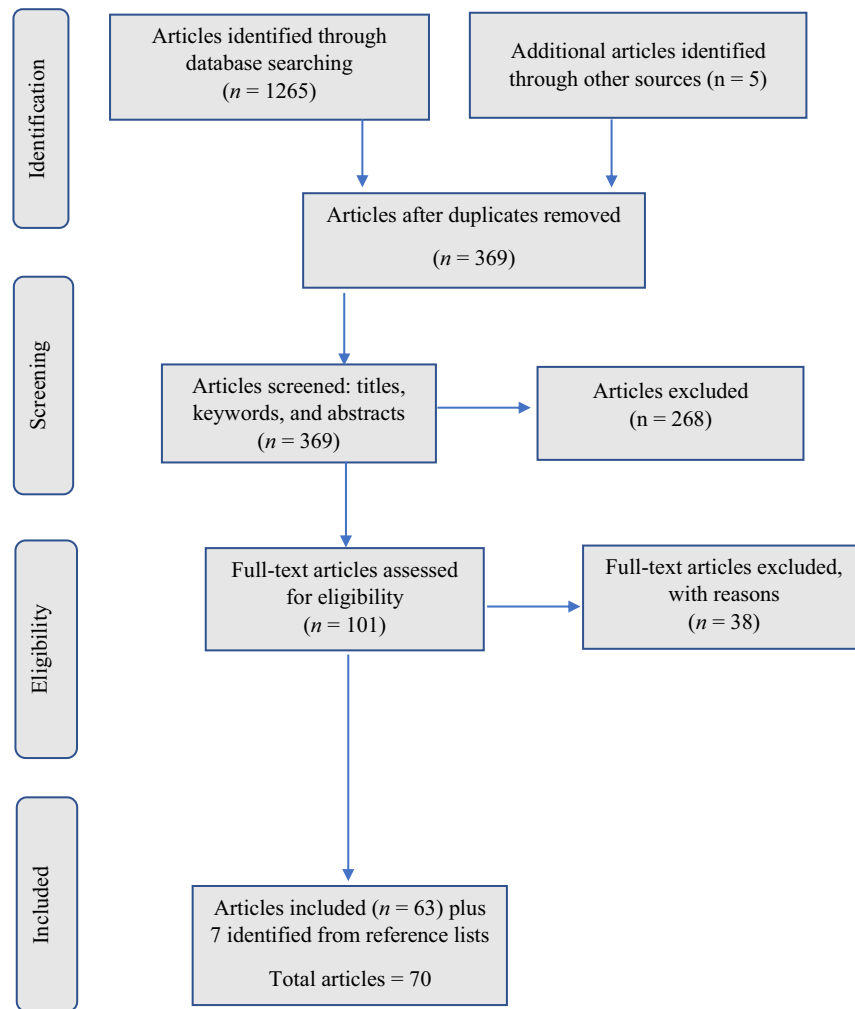
Figure 1. PRISMA flow diagram for the systematic scoping review process. [Colour figure can be viewed at wileyonlinelibrary.com]

in each of New Zealand, Taiwan and Australia. This indicates that a substantial amount of research into word learning has been conducted with English-speaking populations.

To assist with data extraction and to facilitate the summarization of studies, a data charting table was developed to record information about key parameters that researchers varied in the development of their word-learning methodology (the supplementary materials; Peters *et al.* 2015). These parameters were:

- age of participants;
- the learning context (e.g., a play-based or computerized task);
- the modality (oral versus written) and domain (e.g., phonology, semantics or orthographic) of word knowledge that was investigated;
- word-learning stimuli, such as the selection of different word types, the use of real or nonsense words, and/or manipulation of the phonotactic probability;

- task characteristics and methodological details regarding how the stimuli were taught, such as investigation into the impact of learning cues or rate of input; and, subsequently;
- the outcome measures that were used to assess learning.

These parameters are further discussed below.

Age

A total of 39 studies (56%) included only 'young children' with DLD, defined here as children aged 3–6;11. Depending on the country or region of the study, children within this age bracket may have been attending 'kindergarten', 'preschool' or 'pre-primary'. Regardless of terminology, the defining feature is that this cluster of young children had not commenced formal schooling in their respective school systems. A total of 16 studies included 'school-aged' children: those who had commenced formal schooling (Grade/Year 1 and above),

and whose ages ranged from 7 to 13 years. A total of 10 studies examined word learning in both young and school-aged children (e.g., Johnson and de Villiers 2009 included children aged 4–9). The fact that most research was conducted with children reflects the developmental nature of this disorder; the research has aimed to understand the nature of these deficits during critical periods of language and academic development (Kan and Windsor 2010). Feasibility is also a factor, with many studies recruiting preschool and school-aged children with DLD from specialist language schools (e.g., Gray *et al.* 2014).

A substantially smaller number of papers (five) investigated word learning in adults. McGregor *et al.* (2013, 2017a, 2017b) all studied young adults aged 18–25 years, and Alt and Gutmann (2009) included those with a mean age of 19. Except for Bishop *et al.* (2012), who included children and adolescents (mean age of 15 years) and their parents (mean age of 43 years), there were no studies involving 14–17-year-olds or adults aged > 25 years.

Learning context

'Learning context' refers to the situation or task format in which the novel words were presented. A total of 46 studies presented novel words within a structured task, of which 26 were delivered 'live' to each child (e.g., face-to-face, interactive activities with the experimenter and participant), and the other 20 using a computerized task. These tasks, whether live or computerized, involved the child seeing the target object or image and hearing the production of the target word within short sentences or carrier phrases (e.g., *It's a X*; Alt and Spaulding 2011).

A total of 19 studies presented the novel words within a story context. Six of these used an interactive book-sharing task, such as Storkel *et al.* (2017a, 2017b), where the novel words were embedded within a story. Another four required participants to independently read the texts themselves (e.g., Steele and Watkins 2010) in order to investigate orthographic word learning (discussed further in Modality and Domain of Knowledge below). Conversely, nine studies used a digitized story context, such as animated pictures with the novel words embedded in spoken stories (e.g., Horohov and Oetting 2004, Rice *et al.* 2000) or 'simulated' story book reading, where static images were presented on slides alongside an audio recording of the story (e.g., Wolter and Apel 2010). Most studies that presented the novel words within a story context aligned with the principles of a QUIL approach, where the child's attention was not directed to the novel words (to mirror everyday word-learning scenarios, Rice *et al.* 1990).

Four studies examined word learning in more than one learning context. For instance, Nash and Donaldson (2005) explored word learning in a structured task context (e.g., presenting one word at a time accompanied by a definition) compared with a QUIL story context, to determine how the learning situation influences word learning in children with DLD. Smeets *et al.* (2014) compared word learning in two storybook tasks: one presented statically, one via video. The static condition replicated a print version of a book (still images with an audio reading); the video version was similar but used animated pictures and additional sound effects.

One study used a learning context that differed from the others. Bishop *et al.* (2012) presented a modified non-word repetition task, where participants heard and repeated a novel word five times in a row; this task was then repeated 1 h later.

Modality and domain of knowledge

Oral modality

A total of 66 of the 70 included studies (94%) explored word learning in the oral modality. Orally learning a new word involves developing representations for multiple domains of language; however, phonology and semantics are considered the initial aspects crucial to fast mapping (Chiat 2001). Mostly, these tasks involved verbally presenting the novel word along with a visual stimulus (e.g., the unfamiliar object to which the label referred, or a video clip of characters acting out the novel verb), to encourage the development of a form-meaning map (Alt *et al.* 2004). Of the 66 studies, 32 provided only phonological information: the novel word was heard by participants and they were given a visual referent (e.g., a picture representing the novel word), but no attention was directed to its semantic features. The only exception was Bishop *et al.* (2012), who presented the phonological label but no visual referent. A total of 31 of the 66 studies also focused on semantic learning; this involved providing instruction regarding the word's semantic features (e.g., physical attributes or functions; Alt and Plante 2006) in addition to exposure to the phonological form.

Word-learning tasks also involve inherent mapping of a grammatical representation. For example, if a nonsense word is provided with a visual referent (e.g., an object), it could be inferred from context that the word is the label (i.e., a noun) representing the object (Carr and Johnston 2001). However, studies that specifically focused on grammatical learning (e.g., learning to attach morphemes to novel words or learning to use syntactic frames) were not included, as this did not fit with the purpose of understanding learning of whole novel words.

Written modality

Of the 66 studies that investigated oral word learning, three studies additionally examined learning via the written modality (Diestelmeier 2014, McGregor *et al.* 2017a, Ricketts *et al.* 2015). For instance, Diestelmeier (2014) presented the novel words in a verbal task (e.g., saying the word and explaining the meaning). Participants then read the novel words independently in a story reading task. This was intended to encourage development of comprehensive word knowledge (phonology, semantics and orthography) which is required so that the word may be used in both spoken and written tasks (Diestelmeier 2014, Nation 2014).

There were only four studies that primarily investigated word learning in the written modality. For instance, Steele and colleagues presented novel word stimuli via an independent reading task and assessed how well children learned new word meanings (Steele 2015, Steele and Watkins 2010, Steele *et al.* 2013). Similarly, Wolter and Apel (2010) presented kindergarten children with a written fast mapping task, where they viewed an image and written sentences containing the target words. The purpose of this task was to investigate how these children developed initial MGRs, which are significantly related to reading and spelling abilities in later schooling (Wolter and Apel 2010).

Word-learning stimuli

Selection of stimuli: real or non-words

A total of 48 studies (69%) used non-words as their word-learning stimuli to avoid potential confounds from semantic and lexical factors (Kan and Windsor 2010). A total of 23 of these created the non-words, using methods such as random generation (e.g., Alt *et al.* 2004 assigned numbers to phonemes and randomly selected numbers to create CVC or CVCVC non-words), while 25 studies used stimuli that had been developed for a previous study. For instance, Alt and Gutmann (2009) and Alt and Plante (2006) used the non-words created by Alt *et al.* (2004) for their word-learning task. Overall, non-word stimuli were taken from 24 different sources, showing that there is no common 'bank' of non-words used for developing word-learning tasks.

The remaining 22 studies (31%) used real instead of nonsense words as stimuli: these were words that existed in the language but were unfamiliar to participants, as confirmed by pre-testing (e.g., Vogt and Kauschke 2017b) or words considered to be 'low incidence' in children's vocabulary (e.g., Gray 2003). The decision to use real words tended to be ethically motivated, wherein the participants might use those words in future contexts (Gray 2005).

Manipulation of word characteristics

Various novel word lengths and syllable shapes have been explored; 20 studies used only monosyllabic novel words (e.g., CVC, CCVC or CVCC; Steele and Watkins 2010), and 20 studies used disyllabic stimuli (e.g., CVCVC, CVCCVC, CCVCVC; McGregor *et al.* 2017a). A further 13 studies used novel words ranging in length (e.g., two, three and four syllables, Jackson *et al.* 2016). Of these studies, Alt (2011) was the only one to manipulate the length of novel words, and compared the children's ability to learn two- and four-syllable nonwords (CVCVC and CVCVCVCVC, respectively). For 18 studies, it was not possible to determine the syllable shape due to insufficient reporting of information on the stimuli (see the summary table in the supplementary materials).

When creating or selecting stimuli, the phonological properties of the non-words have been considered for potential influence on performance. A total of 10 studies examined the effect of manipulating phonotactic probability (the frequency with which sound segments occur in a language; Gray *et al.* 2014). This factor was explored to determine whether participants with DLD learned novel words with high phonotactic probability more effectively, given their resemblance to other words in the language (Plante *et al.* 2011). Two of these studies additionally investigated the influence of neighbourhood density (the number of words that differ from the target word by just one sound; McKean *et al.* 2014). One of the studies exploring phonotactic probability also explored orthotactic probability (the incidence of a word's graphemes and bigraphs occurring in other English words), which was of interest as the novel words were introduced in a reading task (Wolter and Apel 2010).

Selection of stimuli: word type

Successfully building vocabulary involves learning a range of word types, with concrete nouns considered the simplest to learn given that they can be mapped to a visual referent and are static in nature (Alt *et al.* 2004, Eyer *et al.* 2002). A total of 44 studies used only concrete nouns as stimuli, usually presented as labels or proper names for unfamiliar objects, such as aliens or dinosaurs. Verbs are considered more difficult to learn as they are transient and abstract in nature (Chiat 2001), and 10 papers taught only novel verbs. Tasks for verb learning tended to involve participants watching animated scenarios where familiar objects were made to perform unfamiliar actions, while they heard statements about the action (e.g., *Look, it dacks*; Riches *et al.* 2005). It was not possible to determine the word type for the non-word stimuli used by Bishop *et al.* (2012), as the stimuli were presented in isolation (with not referent).

A total of 15 studies compared learning of at least two different word types to explore how word learning may differ depending on the grammatical function of words (Windfuhr *et al.* 2002). Of these, nine compared learning of nouns and verbs, two compared nouns, verbs and adjectives (Storkel *et al.* 2017a, 2017b), two compared nouns, verbs, attributes and affective states (Oetting *et al.* 1995, Rice *et al.* 2000), one compared nouns, verbs, adjectives and adverbs (Smeets *et al.* 2014), and one compared nouns and attributes (Rice *et al.* 1992).

Task characteristics

To explore factors contributing to word-learning breakdown in people with DLD, a group of studies manipulated the task conditions.

Learning cues

A total of 24 studies (35%) investigated the impact of providing cues during word learning. Eight of these explored the impact of semantic cues (e.g., highlighting the novel word's physical attributes, parts or associations), phonological cues (e.g., providing the first sound, and segmenting and blending the syllables), or both (Diestelmeier 2014, Mundrick 2012, Steele *et al.* 2013).

A total of 12 studies presented novel words in varied syntactic frames to explore how effectively people with DLD use syntactic bootstrapping cues to infer meanings of unfamiliar words (van der Lely 1994). For instance, if a nonsense word is provided with a visual referent (e.g., an object), it might be inferred from context that the nonsense word is the label (i.e., a noun) representing the object. Similarly, if the novel word is provided in a sentence context, you might use syntactic bootstrapping to infer that the word functions as a common noun (e.g., *I see a gaystul*; Alt 2011) or a verb (e.g., *Watch it biff*; Carr and Johnston 2001). Seven of these 12 studies taught novel verbs (e.g., Johnson and de Villiers 2009, Riches *et al.* 2006), four taught nouns and verbs (e.g., Eyer *et al.* 2002, Horohov and Oetting 2004), and one taught only nouns (Rice *et al.* 2000).

Five studies explored the impact of gestural cues on oral learning in children with and without DLD. Comparisons included: auditory-only input versus auditory plus accompanying gestures (Ellis Weismer and Hesketh 1993); iconic versus attention-directing gestures (Luke and Ritterfeld 2014, Vogt and Kauschke 2017a, 2017b); and augmentative pseudo-signs versus no gesture (van Berkel-van Hoof *et al.* 2016). These studies aimed to determine how children with DLD may exploit nonverbal gestural information to strengthen the encoding of, and relationship between, phonological and semantic representations (Vogt and Kauschke 2017a).

Input variations

Some studies explored how effectively people with DLD learned the phonological forms of novel words when the verbal presentations were manipulated (Horohov and Oetting 2004). Three studies manipulated the rate of input, presenting the words in sentences spoken at fast (six syllables per second) or slow (two syllables per second) rates (Ellis Weismer and Hesketh 1993, 1996, Horohov and Oetting 2004). Another three studies explored the impact of varied prosody, presenting the words in utterances that were either emphatically or neutrally stressed (Ellis Weismer and Hesketh 1993, 1998), or that contained the presence or absence of a pause before the target word was said (Rice *et al.* 1992).

Three studies manipulated the number of verbal exposures for each novel word within a training session to determine whether a greater number of exposures yields more accurate establishment of novel word forms (Plante *et al.* 2011). For instance, Rice *et al.* (1994) examined word-learning accuracy when children were provided with three versus 10 verbal exposures to each novel word, and Plante *et al.* (2011) compared one versus 10 exposures. A total of 15 studies explored frequency effects over a series of sessions. For instance, Kiernan and Gray (1998) and Gray (2003, 2004, 2005) presented a word-learning task over 4 days and examined the number of exposures required to reach criterion. This involved presenting the words in a play-based task interlaced with assessment probes and feedback over the 4 days. Within the first session, six exposures were provided, and 24 were provided each day from days 2–4. This allowed examination of learning rate in children with DLD compared with TD children, and provided insight into the number of exposures required for successful vocabulary instruction for these children (Gray 2004).

More recently, Storkel *et al.* (2017b) examined the impact of exposure frequency on children with and without DLD via a book sharing task. Over 4 days, novel words were presented with incremental exposures (12, 24, 36 and 48) to determine an adequate number of exposures needed effectively learn the novel words (Storkel *et al.* 2017b). Similarly, Steele and colleagues explored frequency effects on word learning in the written modality, presenting novel words in 'low rate' (two presentations in the text) and 'high rate' (five presentations) conditions (Steele 2015, Steele and Watkins 2010, Steele *et al.* 2013).

Outcome measures

A range of outcome measures were used to assess word learning. Measures were selected to assess learning in the language domain of interest (e.g., phonology, semantics)

and modality (oral and/or written), and probed receptive and/or expressive knowledge.

Oral outcome measures: phonology

A total of 62 studies (89%) used a receptive (comprehension) task to measure how well participants learned to link the phonological form of novel words to a referent. Frequently (39 studies), a visual identification measure was used: if the novel stimuli were nouns, participants were required to identify the target from an array of pictures when they heard the word (Rice *et al.* 1994, Ricketts *et al.* 2015); for novel verbs, participants saw a selection of action pictures and pointed to the target (e.g., *Show me X-ing*; Oetting 1999), or watched two video clips simultaneously and identified where the action was taking place (Shulman and Guberman 2007). These tasks were scored in an all-or-nothing fashion (e.g., correct/incorrect), and therefore drew on whole-word phonological representations.

Of the 62 studies that used a receptive phonological outcome measure, 23 used a recognition task. Participants heard an array of phonological labels (usually the target label and two or three phonological foils), and judged which were correct or incorrect (e.g., Alt and Gutmann 2009, Ellis Weismer and Hesketh 1998). This task type reflects how effectively participants can recognize the correct phonological form of the target words (Alt 2011).

A total of 35 studies (50%) measured phonological learning using tasks that assessed the expressive link between the referent and what was taught about that referent (e.g., *What's this?* for nouns and *What's it doing?* for verbs; Mundrick 2012, Vogt and Kauschke 2017b). A total of 26 of these were scored as correct/incorrect, thus assessing expressive phonological learning at a whole-word level, while the remaining nine were scored using a measure of accuracy, such as percentage of phonemes that were correctly produced (Jackson *et al.* 2016). Similarly, McGregor *et al.* (2017a) assessed fine-grained phonological knowledge through a stem-completion task, where participants produced the target word after being given its onset sounds. Additional expressive phonology tasks included a sentence-completion task (e.g., *Little kangaroo has jumped into Mama's . . . ?*; Smeets *et al.* 2014), and 'free recall' (recall as many of the 16 novel words as possible in two minutes; McGregor *et al.* 2013), both of which were scored at a whole-word level.

Oral outcome measures: semantics

Like phonological learning, semantic learning was assessed receptively or expressively. Six studies measured receptive knowledge, using tasks such as asking 'Yes/No'

questions about the elements of semantic meaning (e.g., physical attributes or category—*Was gauntlet a sock?*; Nash and Donaldson 2005). Similarly, Alt and Plante (2006) showed isolated pictures of an attribute (e.g., eyes) and asked whether it was a property of the target object's appearance. Tasks that required participants to reflect on deeper semantic knowledge of words in a receptive way included multiple choice tasks requiring them to judge the correctness of the word's definition (e.g., from an array of four options, select the closest meaning for the target word; Steele and Watkins 2010).

A total of 14 studies assessed the ability to express semantic knowledge of the target items. They employed tasks which varied by either directly or indirectly tapping into the taught semantic information. For example, Gray (2005) used a drawing task to assess recall of physical features (scored from 1 to 7 according to the degree of accuracy and completeness). Horohov and Oetting (2004) asked participants to provide synonyms for the target items (*Tell me a real word that means the same thing as X*), which required the children to build understanding of the novel word and create links with existing vocabulary. This was scored using in-depth error analysis, looking for how well synonyms matched the target in meaning and syntax (Horohov and Oetting 2004). Similarly, McGregor *et al.* (2013) used a word association task (i.e., say the first word that comes to mind when you hear the name of each target object), scored according to whether the response was semantically related.

Most studies that measured semantic learning (10) used a definition measure (e.g., *Tell me what X means*; Storkel *et al.* 2017b). These tasks were often scored according to the inclusion of component parts of a definition (Nash and Donaldson 2005), and in nine studies these were delivered dynamically, with graduated prompting provided depending on the completeness of the oral definition provided (e.g., contextual cues or forced choice prompts were given if required; Steele 2015).

Written outcome measures

As outlined in the section above on Modality and domain of knowledge, three studies examined word learning in both the oral and written modalities (e.g., Diestelmeier 2014). Of these, Diestelmeier (2014) used an oral definition task as the sole outcome measure. While the word-learning task involved both oral and written input, the purpose was to explore how well participants would use the written task to develop word meaning, so no orthographic outcome measures were included. McGregor *et al.* (2017a) used oral measures (e.g., a stem-completion task) and an orthographic task requiring letter identification. Ricketts *et al.* (2015) used

a visual identification task to determine oral learning of the word's phonology, and a spelling task to measure learning of the orthographic representation.

Four studies measured word learning only in the written domain. Wolter and Apel (2010) used a pseudoword generation task, requiring participants to spell all target items to dictation, and a pseudoword identification task (find the written word from three foils), as a measure of receptive orthographic knowledge. The remaining three (Steele 2015, Steele and Watkins 2010, Steele *et al.* 2013) provided written input and only used oral definition measures. Thus, these tasks were designed to measure how children learned novel words through reading, such as their use of decoding skills and using contextual information to build meaning (Steele *et al.* 2013).

Discussion

The aim of this scoping review was to review the state of knowledge and identify gaps in the literature with regards to word-learning evaluations in people with DLD. The results highlighted an impressive variety of tasks; each of the 70 reviewed studies developed a new method, or modified one used previously, to investigate specific aspects of word learning. Despite this variability, the literature was united in its aim: to build understanding of why word learning is a problem for people with DLD. This systematic scoping review summarized the research by discussing several key methodological parameters considered by researchers in developing a word-learning task. Here, we discuss further how these methodological decisions are generally driven by the theoretical perspective of the research team regarding potential cause of word breakdown in DLD. Understanding these theoretical perspectives allows insight into theory-driven elements of word learning that have been well-investigated, as well as gaps in the knowledge base that may guide future research.

Much of the literature explored word learning in people with DLD from a 'performance-based' perspective, which focuses on the cognitive constraints potentially underlying difficulties with how information about new words is processed, stored, and retrieved (Evans 2001, Kan and Windsor 2010). Various performance-based accounts have been considered, with some researchers considering generalized processing deficits and others exploring deficits in specific mechanisms (such as phonological processing; Ellis Weismer and Hesketh 1998). Other researchers adopted a linguistic perspective to frame their methodology, exploring the notion that deficits in the grammatical system may account for difficulties with using syntactic cues in word-learning tasks to extract information about new word forms and meanings (van der Lely 1994).

Some studies designed methods to investigate whether word-learning difficulties in DLD may be due to generalized limitations in processing capacity (Nation 2014). Usually, this involved manipulating the conditions of the task (i.e., learning context and/or task characteristics). Studies that presented the novel words in more structured contexts with exposures to the novel words in a focused, explicit manner (e.g., Nash and Donaldson 2005) likely minimized processing demands, allowing the allocation of cognitive resources to the identification, processing, and storage of the phonological and semantic representations for novel words. However, others explored whether presenting novel words in stories with added sound effects and animations had a detrimental impact on learning novel words, potentially due to the diversion of limited cognitive resources to additional linguistic and non-linguistic cues during learning (Smeets *et al.* 2014).

Attentional abilities were mentioned in the literature as being a potential factor impacting general processing capacity for word learning (e.g., Alt and Spaulding 2011), yet this was not explicitly explored in any of the included studies. Ebert and Kohnert (2011) found that children with language impairments often exhibit attention deficits, thus the influence of attention on word learning should be further explored. A generalized capacity perspective would predict that attention would especially impact how people with DLD learn novel words in tasks that require processing and integration of multiple sources of information, or in conditions with numerous potential distractors (Alt 2013, Alt and Gutmann 2009).

Many studies explored word learning from a performance-based perspective and focused on whether deficits in the specific mechanisms involved in phonological processing may account for word-learning difficulties (e.g., Ellis Weismer and Hesketh 1996, Horohov and Oetting 2004). A phonological processing theory is grounded in evidence that people with DLD experience inherent deficits for processing, storing and retrieving sound-based information. Earlier studies that adopted this view explored factors related to input processing of the stream of speech. For instance, Rice *et al.* (1990) and Rice *et al.* (1992) manipulated task input variables by embedding the novel word at the end of an utterance and inserting a pause before and after. Others presented the novel word in connected utterances at either fast or slow rates or using emphatic versus neutral stress (Ellis Weismer and Hesketh 1993, 1996, 1998, Horohov and Oetting 2004). These studies aimed to test the hypothesis that word-learning abilities in children with DLD break down when the task demands exceed the child's available resources for processing phonological information (Horohov and Oetting 2004). While various task factors have been explored, future research may focus on

investigating word-learning contexts that are linguistically facilitative for people with DLD.

Other studies, also drawing on a phonological processing perspective, explored the impact of manipulating the phonological properties of novel words. Specifically, novel words with high versus low phonotactic probability were used to determine how well people with DLD were able to draw on existing phonological forms in vocabulary to facilitate establishment of new word forms (Alt and Spaulding 2011, Gray and Brinkley 2011). Similarly, learning ability for novel words with high versus low neighbourhood density was explored, but only in two studies (Gray *et al.* 2014, McKean *et al.* 2014). Gray *et al.* (2014) argued the importance of considering both aspects when selecting stimuli for word-learning tasks, as people with DLD (who tend to have restricted vocabularies) may be disadvantaged when presented with novel words that are phonologically like those in their language. Thus, future research may investigate the impact of both phonotactic probability and neighbourhood density.

Other studies drew on a performance-based approach but focused on the involvement of memory processes in word learning (Alt 2011). Specifically, to explore the notion that word-learning difficulties may result from deficient encoding and long-term retention of novel word information, researchers explored whether a higher number of encounters would facilitate more accurate establishment of phonological and semantic forms in long-term memory (Riches *et al.* 2005). This was tested in numerous studies through manipulating the task characteristic of frequency of exposures (e.g., Gray 2003, 2004, 2005, Kiernan and Gray 1998, Storkel *et al.* 2017b). While these studies generally found that more exposures facilitated effective word learning for DLD participants, except for Storkel *et al.* (2017b) no research explored an 'optimal intensity' required to reach mastery of learning. Further research could explore optimal intensity of word-learning instruction for various age groups to inform intervention strategies and instructional approaches.

Other studies grounded their methodologies in a linguistic perspective, exploring the notion that deficits in the grammatical system of people with DLD impact their ability to use syntactic bootstrapping abilities to infer crucial information about the form and meaning of novel words (Eyer *et al.* 2002). Several studies presented novel words in varied syntactic conditions to evaluate how effectively children with DLD tune into the cues provided by syntactic structures (e.g., Johnson and de Villiers 2009, Steele and Watkins 2010) or morphological markers (e.g., Carr and Johnston 2001, Eyer *et al.* 2002) associated with the novel word. While syntactic bootstrapping was mostly explored in relation to verb learning (e.g., Carr and Johnston 2001, Eyer *et al.* 2002,

O'Hara and Johnston 1997, Riches *et al.* 2006), its influence was also investigated in teaching different types of nouns (i.e., count and mass nouns; Rice *et al.* 2000), and the influence of varied syntactic cues for noun (object names) and verb (action) learning was also compared (Horohov and Oetting 2004).

A small number of studies also explored the influence of syntactic bootstrapping on learning novel adjectives, adverbs, prepositions, and conjunctions (Oetting *et al.* 1995, Storkel *et al.* 2017a, Rice *et al.* 1990, 1992). However, in comparison with noun and verb investigations, the exploration of how well people with DLD learn these other word types has been limited. Research indicates that this population is likely to especially struggle to learn these types of words given their abstract nature and subsequent need to rely on sentential context and morphology to derive meaning (Shulman and Guberman 2007, Chiat 2001), and so this should be the focus of future research.

Regardless of the theoretical perspective driving the various methodologies, most research included in this review focused on learning novel words in the oral modality. While some studies additionally included orthography as a learning 'cue' for the oral word-learning task, only four studies focused exclusively on how people with DLD learned novel words through orthographic input. It would be expected that dual deficits for learning words through the oral and written modalities would emerge for many people with DLD given the evidence that this population may struggle with one or more of the component skills involved in reading (Catts *et al.* 2005). For instance, weaknesses in phonic knowledge and phonemic awareness skills could impede the ability to decode novel words and thus establish an orthographic representation (Wolter and Apel 2010), as could weaknesses in the use of language comprehension skills to infer the meaning of novel words (Steele and Watkins 2010). Further research into how people with DLD learn novel words through reading is crucial to address this gap in this literature. Learning novel words through reading is an important phenomenon to explore given that 'reading is a primary source of vocabulary development in the upper elementary years' (521).

Finally, a significant gap in the literature arose regarding the investigation of word learning in adolescents and adults with DLD. This may reflect issues with recruitment, such as a lack of dedicated education sites for adolescents and adults with DLD from which to recruit. Additionally, issues with retrospective reporting of developmental impairments may contribute to difficulties recruiting adult participants. For instance, adults may underreport their impairments or confuse language difficulties with literacy problems (Alt and Gutmann 2009). Given that adolescents and adults are required to continually learn new vocabulary, especially when

entering a new workplace where new jargon is frequently used (Alt and Gutmann 2009), further research should be conducted on their word-learning capabilities in both oral and written domains.

Summary and future directions

In this scoping review, a total of 70 studies were examined to explore the current state of knowledge regarding evaluation of word learning in the DLD population and to identify gaps in the literature. The review identified a paucity of research into word learning in adolescents and adults with DLD and limited investigation into learning novel words via the written modality. Other gaps in the literature include limited exploration of learning word types other than nouns and verbs. It is hoped that the findings of this review provide a foundation from which further research may be developed.

Future research efforts may be directed toward the clinical application of word-learning assessments. While the purpose of this scoping review was not to compare word-learning performance of people with DLD to those with typical language development, it is apparent that word-learning deficits in this population are well-established. Thus, a task that dynamically assesses word learning seems a valuable addition to the assessment battery for speech and language therapists (SLTs). Future research may consider how best to translate the methods used in research contexts to clinical practice, so that SLTs are equipped with the resources to investigate the nature of word-learning abilities in their clients with DLD.

Acknowledgements

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Supplementary Materials