Morphemes Matter: a small scale Randomised Control Trial of vocabulary intervention focusing on affixes for adolescents with (developmental) language disorder.

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Abstract

Purpose. To investigate whether morphological intervention improves understanding of affixes in adolescents with a language disorder and whether progress generalises.

Method. 25 adolescents aged 13-15 years participated in this single-blind trial with random allocation. All participants had a language disorder; 18 with developmental language disorder (DLD), 4 with associated genetic conditions and 3 with autism. 11 participants received twice-weekly morphological intervention for 30 minutes with a speech-language pathologist (SLP) for eight weeks, while 14 received intervention as usual. Two tests were administered pre- and post-intervention: affix definition and an adapted rehit task, which tested participants' ability to work out the meaning of novel words containing affixes. To investigate generalisation to untaught affixes, only half of the affixes were taught in intervention.

Result. Those in the intervention group made significantly more progress than controls on both tasks, but only on taught affixes. Therefore, learning generalised to understanding the meaning of taught affixes in combinations with new roots (adapted rehit task) but did not generalise to untaught affixes on either task.

Conclusion. The intervention was effective and learning generalised to other words containing taught affixes. Intervention for affixes has potential to greatly increase understanding of vocabulary following relatively small amounts of intervention.

keywords: vocabulary, developmental language disorder, morphology

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Introduction

Understanding and using words is a vital part of children's language development. Children with larger vocabularies at two years show greater academic achievement by five years (Morgan et al., 2015), while below-average vocabulary knowledge on school entry is associated with poorer academic, mental health and employment outcomes in adulthood (Law et al., 2009). Typically, children learn vocabulary incidentally through exposure to language and this learning is reinforced through practice and corrective feedback (Bloom, 2000). Typically-developing children acquire new words at a remarkable rate, with some estimates suggesting an average of nine new words per day between the ages of 18 months and six years (Carey, 1978), and a vocabulary of around 20,000 different words by age 10 (Nippold, 2016). However, some children have difficulty learning vocabulary, often due to underlying language difficulties.

Developmental language disorder (DLD) is a neurodevelopmental disorder characterised by difficulties with language comprehension and/or production in the absence of a known biomedical condition (Bishop et al., 2017), affecting around 7.6% of children on school entry (Norbury et al., 2016). This latter study also found an additional 2.3% of children have a language disorder associated with another condition, such as autism spectrum disorder (ASD), a genetic condition or deafness.

Children with DLD have deficits in word learning and word knowledge (Kan & Windsor, 2010; Nation, 2014) which are part of a broader profile of language difficulties, including difficulties with grammar (Leonard, 2009). Children with DLD show deficits in both the breadth (the number of words known) and depth (how much is known about those words) of their vocabulary knowledge relative to typically-developing peers (McGregor et al., 2013). They learn fewer novel words than typically developing children of the same age (e.g., Ellis Weismer & Hesketh, 1996; Nash & Donaldson, 2005; Rice et al., 1992) and are less able to derive word

meanings from context (Cain et al., 2004; Mckeown et al., 1985). As they get older, vocabulary weaknesses pose particular challenges, as the types of words in curriculum materials become more abstract and morphologically complex (Dawson et al., 2023; Nagy & Townsend, 2012; Nagy & Anderson, 1984). Thus, developing effective interventions to expand the vocabularies of children and young people with DLD (and indeed children with language disorder associated with other conditions) is important in supporting their access to education and promoting positive long-term employment outcomes.

Promisingly, intervention has been shown to be effective in teaching new words to students with DLD of various ages, including to adolescents (Ebbels et al., 2022; Joffe et al., 2019; Lowe et al., 2019; Lowe & Joffe, 2017; Wright et al., 2018). The main focus of such intervention is usually on the semantics and phonology of individual words. However, a major challenge is that the number of words learned in these studies is often low with little to no evidence of generalisation to untaught words. It is not possible to teach all words explicitly via intervention, therefore identifying and targeting strategies that promote generalisation of word knowledge is key to supporting vocabulary growth, especially for children with vocabulary learning weaknesses, such as those with DLD. Extending vocabulary intervention beyond semantics and phonology to include much greater focus on morphology is a promising avenue that could capitalise on the fundamentally systematic nature of the language system whereby many words in English combine root words (e.g., *lock*) and affixes (e.g., *un-*; *-able*) to form morphologically complex words (e.g., *unlockable*). These components (roots, prefixes and suffixes) are known as morphemes, the smallest meaningful units of language. This study focused specifically on derivational morphology, where new words are formed by adding prefixes or suffixes to a root or base word. Derivational processes often alter the word's meaning or grammatical category (e.g., *lock – unlock*; *happy – happiness*). Knowing the function and meaning of morphemes may therefore support generalisation to new words containing the same roots and affixes (e.g., *relock*; *unreadable*).

Morphological Awareness and Analysis

Morphological awareness is the ability to detect and manipulate morphemes in words (Carlisle, 1995). This supports the process of working out the meanings of unknown morphologically complex words by combining the meanings of individual affixes and roots, a process sometimes referred to as morphological analysis (Baumann et al., 2002; Larsen & Nippold, 2007). Several studies indicate a close relationship between morphological awareness, morphological analysis and vocabulary (McBride-Chang et al., 2008; McBride-Chang et al., 2005; Nagy et al., 2006; Sparks & Deacon, 2015). Thus, focusing on morphological awareness and analysis may be an efficient intervention method for expanding the vocabularies of children with DLD. This is the aim of the current study.

In typical development, children demonstrate sensitivity to morphological patterns from an early age (Berko, 1958; Brown, 1973) as shown by over-regularisation errors of past-tense forms (e.g., *goed* instead of *went*). However, the ability to engage in conscious manipulation of words based on morphological rules emerges slightly later, in the early primary grades (Carlisle, 2003; Larsen & Nippold, 2007) and continues to develop well into late childhood (Anglin et al., 1993). The most rapid growth of morphological awareness and morphological analysis occurs between fourth and eighth grade as more morphologically complex words are introduced in books that students are reading and in classroom curricula (Freyd & Baron, 1982; Fumero & Tibi, 2020; Templeton & Scarborough-Franks, 1985). For children with typical language development, knowledge of morphological regularities may develop via encounters with morphologically complex words in written and spoken contexts. However, for children who find language and vocabulary learning difficult, such as those with DLD, explicit instruction may enhance this process and may be especially helpful.

A number of studies have examined the effects of morphological instruction on a range of areas related to literacy (for summaries see Bowers et al., 2010; Carlisle, 2010; Goodwin & Ahn, 2013; Reed, 2008) and several studies with typically developing children show that intervention

including morphological analysis improves their ability to work out the meaning of untaught words containing taught affixes (Apel et al., 2013; Apel & Diehm, 2014; Baumann et al., 2003; 2002). We were interested in whether similar effects of morphological intervention on vocabulary-related outcomes could be found in children with identified language difficulties. Some existing studies focused on this group and intervention, but had reading and spelling outcomes, rather than vocabulary outcomes (Kirk & Gillon, 2009; Wolter & Dilworth, 2014). Others did have vocabulary outcomes (Gellert et al., 2021; Spencer et al., 2017), but while the participants had weak vocabulary, they did not have identified language difficulties.

The intervention in Spencer et al. (2017) had morphological intervention as only a small component of their intervention and therefore its specific contribution cannot be evaluated. The study by Gellert et al. (2021) in contrast, focused specifically on morphological awareness and analysis and thus merits further discussion here. The Gellert et al. (2021) study compared the outcomes of fifth grade children with limited vocabulary who received the morphological intervention with those of control groups of similar children who received either context-based vocabulary intervention (with no focus on morphology) or 'business as usual'. The group that received the morphological intervention showed more generalisation to real words including taught affixes and roots (but in different combinations) and to pseudowords containing taught affixes than those in the two control groups.

The participants in Gellert et al. (2021) did not have identified language difficulties, but rather were the 12 children per class with the weakest vocabulary (but with no indication of dyslexia, hearing impairment or autism). For half of the participants, the language of instruction was their second language and this group performed significantly lower than the others. Therefore, while some of the children may have had DLD, it is hard to disentangle those participants in the Gellert et al. (2021) study with limited experience with the language from those with language learning difficulties.

We are aware of only three studies where morphological awareness or analysis intervention was delivered to children with identified language difficulties. Two had no experimental control and involved only one (McLeod & Apel, 2015) or three children (Katz & Carlisle, 2009); thus we will not consider these further. The other (Good et al., 2015) included 16 children with a diagnosed language impairment in a small-scale randomised control trial where the children were exposed to words containing specific affixes in groups of 2-4 children with a speech-language pathologist (SLP). In this study, the effects of intervention on reading, spelling and vocabulary were considered. The children in the experimental intervention were encouraged to identify common orthographic patterns and meanings associated with the targeted affixes and were given feedback to encourage this, whereas the control group encountered the same words, but no discussion took place of how to split them into roots and affixes. The experimental group improved more than controls on both spelling and vocabulary (but not reading). For vocabulary, taught words were significantly better understood post-intervention than untaught words. The experimental group also showed evidence of generalisation to untaught words, unlike the control group.

The Good et al. (2015) study focused on morphological awareness (i.e., how to split words into constituent parts), but not morphological analysis (i.e., they did not discuss or practise using these parts to work out the meaning of unknown words). In her integrated review, Carlisle (2010) identified four basic instructional approaches, of which only the first two were used in the Good et al. (2015) study: 1) increasing awareness of morphological structures within words, 2) increasing knowledge of the meanings of affixes and roots, 3) supporting morphological problem-solving and 4) using morphological analysis to work out the meanings of unfamiliar words. Therefore, it is possible that greater generalisation of intervention than that found in Good et al. (2015) could be achieved for children with DLD if morphological analysis were also included as an explicit component of intervention. We therefore included morphological analysis in our intervention.

Previous studies have shown that children with DLD respond well to explicit instruction in the areas of both grammar (Balthazar et al., 2020; Ebbels, 2014) and vocabulary (Campbell et al., 2019; Ebbels et al., 2022; Joffe et al., 2019; Lowe et al., 2019; Lowe & Joffe, 2017; Wright et al., 2018). However, in many of the vocabulary intervention studies, low numbers of words were learned and there was little evidence of generalisation to other words. The Good et al. (2015) study is promising however, as it showed generalisation to other words. Thus, further investigation is warranted of the potential of including morphological awareness and expanding this to include morphological analysis in intervention aiming to improve vocabulary for children and young people with DLD.

Given that vocabulary becomes increasingly morphologically complex in secondary curriculum materials (Nagy & Townsend, 2012; Nagy & Anderson, 1984), our study focuses on secondary-aged children with language disorder. Our intervention targeted: 1) morphological awareness focusing on segmenting and blending prefixes, roots and suffixes, 2) explicit instruction of the meanings of individual affixes and 3) morphological analysis combining the meaning of known roots and taught affixes to work out the meanings of multimorphemic words. The aim was to increase participants' ability to understand and work out the meanings of multi-morphemic words containing common affixes, which in turn might support the development of maths, science and social sciences vocabulary.

Research Questions

In this study, we investigated the effectiveness of morphological intervention on the ability of adolescents with language disorder to define taught and untaught affixes and infer the meaning of novel words involving these affixes. We aimed to answer the following three research questions:

1. Do participants in the intervention group make more progress overall with intervention than those in the control group?
2. Do participants in the intervention group make more progress on taught than untaught affixes?

3. Do participants in the intervention group make more progress than participants in the control group on untaught affixes (i.e., do they show generalisation to untaught affixes)?

Method

Study Design

This single-blind trial (where testers and scorers were unaware of group allocation) with random allocation to groups investigated the effectiveness of paired morphological awareness and analysis intervention delivered by an SLP for secondary-age students with a language disorder, the majority of whom met criteria for DLD. The intervention group received the experimental intervention twice per week for 30 minutes in pairs for one school term, while the control group received intervention as usual. Those participants in the intervention group were randomly assigned to be taught one of two lists of affixes. Thus, for the control group, all of the affixes were untaught, while for those in the intervention group, one list served as taught affixes and the other list as untaught affixes.

We had planned a crossover design where the experimental intervention would be given to the (waiting) control group the following school term, with re-testing at the end of that term to test for maintenance of any progress in the original intervention group and to establish whether the waiting controls showed similar progress with intervention. However, due to the COVID-19 Public Health Emergency in 2020-2022 and related school closures, the second crossover phase of the study was abandoned. If schools had re-opened with sufficient weeks left in the term, we would have carried out the intervention, but this did not happen. The approaching COVID-19 lockdown also led us to bring forward the post-intervention testing so that the intervention group received one week less intervention than originally planned (total of 8 weeks). This decision was taken by the first four authors and the last author in order to ensure that we had post-intervention data.

Ethics

This study was approved by the Moor House Ethics Forum (reference number 2019/2).

Participants

The study was carried out at a specialist school for children with language disorders in the United Kingdom. All students attending this school participate in a rigorous assessment process prior to entry and language has been deemed to be the primary barrier to learning for these students. Our sample was a convenience sample where all students in Years 9 and 10 (aged 13-15 years) at the start of the first intervention period, regardless of diagnosis or co-occurring difficulties, were invited to participate in the study (N=39). Participant flow is illustrated in Figure 1. Consent was obtained for 34 students. Eight students were then excluded from the study as their primary SLP judged that other areas of speech, language or communication were higher priority for intervention. One participant (ID5) withdrew from the study partway through the intervention period, due to needs prioritised in other areas. Twenty-five participants (seven females and 18 males) remained, with a mean age of 14;03 (13;04-15;02) years at the start of the intervention.

All participants had a language disorder as defined by Bishop et al. (2017). The majority (18) met the criteria for DLD and the others had a language disorder associated with another condition (three with ASD and four with genetic conditions). Thus, we will refer to the cohort in this study as having (D)LD. Many of the participants also had co-occurring conditions: dyslexia (8), dyscalculia (3), attention deficit hyperactivity disorder, ADHD (5), dyspraxia (3), childhood apraxia of speech, CAS (2), developmental coordination disorder, DCD (2), sensory processing disorder, SPD (1). One participant lived in a bilingual household (English and Dutch) but was himself a monolingual English speaker. All other participants were monolingual English speakers.

A regular assessment cycle was used in the school, with all students tested annually on the Wide Range Achievement Test, Fifth Edition (WRAT 5, Robertson & Wilkinson, 2006), and assessed on the Clinical Evaluation of Language Fundamentals (CELF) and British Picture

Vocabulary Scale (BPVS) at the beginning of Year 7 (aged 11), the end of Year 9 (aged 14) and the end of Year 11 (aged 16). On the first testing for each student, the most recently published version of each test was used. For progress monitoring purposes students were then tested on the same version of the test for subsequent testing (even if a newer version had since been released). Therefore, participants in the study completed either the 4th or 5th edition of the CELF (CELF-4, Semel et al., 2006; CELF-5, Wiig et al., 2017), and either the 2nd or 3rd edition of the BPVS (BPVS-3, Dunn & Dunn, 2009; BPVS-II, Dunn et al., 1997).

For the purposes of this study all participants were also assessed on the Word Derivations Subtest from the Test of Adolescent and Adult Language - Fourth Edition (TOAL-4, Hammill et al., 2007). The Word Derivations Subtest assesses the ability to orally produce a derived form of a word that is missing from the end of a spoken sentence (e.g., Tester: "Explode. We knew it would be a terrible noise. From a mile away we heard the…" Participant: "explosion"). This subtest was chosen to provide additional information related to morphological awareness and was intended to be re-administered after intervention, to act as a measure of generalisation. However, due to the COVID-19 pandemic and related school closure, we could not re-administer this assessment task. Participants' most recent test results in language, reading and word derivations prior to entering the study are presented in Table 1 and their individual data in Appendix A. These show that all participants had language difficulties, including difficulties with derivational morphology, but their scores on reading accuracy varied. There were no significant differences between the intervention and control groups on any of the standardised measures or in age pre-intervention.

Randomisation

Following the pre-intervention assessment, participants were randomly assigned to intervention and waiting control groups by the last author using the random number function in Excel which generated a random number between zero and one for each participant. Participants were first sorted into a random sequence by their random number, the sequence was then split into two

groups with an even number of participants (12) in the intervention group to allow paired intervention (i.e., the 12 participants with the lowest random number were assigned to the intervention group). The first and last authors then confirmed that the groups did not differ significantly on standardised measures of language (see section on Participants and Table 1).

Participants in the intervention group were then allocated to six intervention pairs, first by academic year group (for ease of timetabling, four Year 9 pairs and two Year 10 pairs) and then by pre-intervention scores (students with similar pre-intervention scores on experimental measures were paired together).

Intervention

Paired intervention took place for 30 minutes with an SLP twice a week. The original plan was for intervention to continue for nine weeks (a total of 18 sessions, nine hours). Due to the COVID-19 pandemic and related imminent school closure, the planned duration was cut short by one week (down to eight weeks), which meant that the post-intervention assessments were brought forward.

Study Procedure

Intervention was delivered by participants' usual SLP or an SLP familiar to them from within the school, as part of their typical speech pathology service at the school. Sessions were conducted in a quiet room on the school site. Four SLPs were involved in delivering the intervention - two worked with Year 9 students and two with Year 10 students. Two of these SLPs designed the intervention (first and second authors together with the third author) and the two other SLPs received training from the first author. This training involved a one-hour meeting with each individual SLP to explain and demonstrate the intervention. All SLPs delivering the intervention were provided with a printed folder that included background information on the approach, an explanation of each individual therapy technique, scripted student friendly definitions and gestural cues for each affix, scripted lesson plans and printed materials for each lesson. The SLPs worked together full time in the school so any queries or concerns could be discussed and resolved

quickly. Teaching of morphological awareness, affix meanings and morphological analysis for the intervention group only took place in paired intervention sessions, with typical classroom instruction and additional typical SLP intervention (group and in-class support) focusing on other aspects of language. Two participants from the intervention group received additional individual sessions from their usual SLP throughout the treatment period, but these sessions focused on speech production skills rather than language.

The control group received intervention as usual (twice-weekly individual and/or paired intervention, group intervention and in-class support), for the same duration, delivered by their usual SLP. There was no significant difference in minutes of intervention received by the two groups overall (p=0.3). Intervention for those control group included a focus on semantic organisation, listening and reading comprehension, syntax, phonology, articulation or discourse. No participants in the control group received intervention focusing on morphological awareness, affix meanings or morphological analysis.

Affix selection

The study targeted understanding and use of common affixes to support the development of curriculum vocabulary including maths and science words. Twenty-one prefixes and five suffixes were selected as intervention targets. Affixes were selected with reference to previous publications including Apel et al. (2013), Baumann et al. (2002), Goodwin et al. (2012) and Zoski et al. (2018). This was followed by consultation with the school's mathematics and science teachers to ensure that the selected affixes were functional and related to core topics in the curriculum. Affixes were then grouped into semantically related groups (e.g., number: *milli-, cent-, tri-, bi-*) as suggested by Baumann et al. (2002) and Goodwin et al. (2012). These groups of affixes were then split into two lists, each with similar numbers of affixes from each semantically related group, shown in Table 2.

Method and Order of Instruction

The experimental intervention was devised by the first three authors and used direct and explicit teaching of the meanings of affixes with guided application at the word, sentence, and paragraph level.

The intervention included one introductory session, 14 teaching sessions and five review sessions, delivered in the order outlined in Table 3. The introductory session included explicit teaching of the concepts of root, prefix and suffix and brief explicit teaching (definition and an accompanying gesture) of all target affixes. The teaching sessions targeted one affix per session (ordered in semantically related groups as previously stated – see Table 2). After all affixes in a particular semantic group were taught, participants received a review session for those affixes. The order of instruction of affix groups was based on pre-intervention testing results (mean scores across all participants for individual affixes, ranked from easiest to hardest). Intervention started with the easiest affixes and moved onto harder affixes later. Each intervention session started with a review of all taught affixes and their meanings. A 'basic set' of inflectional morphemes, which included plural *-s/-es*, possessive *–'s*, past simple *-ed*, and present progressive *-ing* was also included in each intervention list. This 'basic set' was not included in any pre- and post-testing and was used as part of the initial explicit teaching for the concepts prefix, suffix and root in the introductory session. The basic set affixes were familiar to all students in the study and were identified as some of the earliest developing morphemes in previous publications (Apel et al., 2013).

Intervention Principles

The overarching principles used within this intervention are outlined in Table 4. The intervention protocol is presented in Supplementary Information 1, described using the Template for Intervention Description and Replication (TiDier) framework (Hoffmann et al., 2014).

Components of the Intervention

Introductory Session. In the first session, participants were introduced to the purpose of the intervention and taught the meaning of the vocabulary *prefix, suffix* and *root,* using an explicit teaching poster (see Supplementary Information 2). Following this initial teaching, the SLP presented visuals for all target affixes in the participants' intervention list. Each visual had a picture, the written affix and a simple definition (see Supplementary Information 3). Using modelling, imitation and retrieval practice, the SLP and participants named and defined each affix in their list. Pre-determined gestures for each affix were also used during this explicit teaching phase to act as an additional 'cognitive hook' to support learning and retrieving of affix meanings. The final task in the introductory session involved students completing a morpheme blending activity which included a printed root word in the middle of a page with blank squares in the prefix and suffix positions. Using a pile of printed cards containing written prefixes or suffixes, the SLP and participants took turns to add affixes to the given root and generate as many real words as they could. These words were then written on the page.

Main Intervention Sessions. The main intervention sessions followed the structure below:

1. SLP share learning intention for the session.
2. Review meaning of *prefix, suffix*, and *root* using the explicit teaching poster (Supplementary Information 2)
3. SLP and participant review (say, read and gesture) all intervention and basic set affixes and their definitions (Supplementary Information 3).
4. Explicit teaching of target affix for the session using a student-friendly definition, gesture and picture, with modelling, imitation, repetition and retrieval practice
5. SLP and participants fill in an affix mat for the target affix. The affix mat was a graphic organiser that included the target affix in the middle of the page and boxes around the page

with space for the participant and SLP to write a definition of the affix, write example words using the affix and write a sentence containing one of the words.

6. Complete morpheme study table (Supplementary Information 4). The morpheme table was a graphic organiser that included four words containing the target affix. SLP and participants identify the prefixes, suffixes and roots and their meanings in each word, define the words and discuss how each affix contributed to the meaning, use the words in sentences, and draw pictures to depict their meaning.
7. Complete reading comprehension task (see Supplementary Information 5) using a passage containing multiple examples of the target affix. Participants identify words containing the target affix and discuss the overall meaning of each word, in relation to the individual meanings of the morphemes.
8. Participants and SLP complete a reflection sheet (see Supplementary Information 6) to summarise learning from the session.

For more detail about the main intervention components including example scripting, see Supplementary Information 7.

Review Intervention Sessions. In the review sessions the meanings of previously taught affixes within that semantic group were reviewed and participants completed a review sheet (see Supplementary Information 8). Review sheets included affix to definition matching, cloze sentences, and generating and defining words containing taught affixes.

Intervention Fidelity

To support fidelity all four delivering SLPs were given an intervention file that included scripts for introducing tasks, scripted definitions of target affixes and strategies for scaffolding and extending performance. Attendance and intervention fidelity were recorded through use of a checklist which was completed by the delivering SLPs at the end of each session. SLPs were

asked to report any deviation from the session plan. When participants were unable to attend a session, SLP discretion was used to adapt the intervention plan, by either combining activities for two affixes into one session or leaving out that session.

In terms of attendance, participants attended an average of 14.3 of the planned 18 intervention sessions (range: 12-15). Reduced attendance rates were mainly due to school closure related to the COVID-19 pandemic which led to the post-intervention assessment being brought forward by one week (two sessions). Attendance was also affected by staff and student absences in the weeks leading up to the national lockdown in the U.K. In the last two to three weeks, when either students or the SLP had been absent, two affixes in adjacent sessions were taught together in the following session to try to cover all affixes. To achieve this, the first author worked with each SLP to adapt these sessions - most often by reducing the number of words taught for each affix and/or omitting the reading comprehension task from the session. This attempt to cover all affixes was partially successful: four participants received some intervention for all 13 affixes, four participants received intervention for 12 affixes, one participant for 10 affixes and two participants for only nine affixes. The final review session was not completed for nine out of 11 of the participants.

Assessment Tasks

All assessments were carried out in an individual setting by either a qualified SLP or an SLP assistant who were blind to group status but trained in administering the assessments. All participants were tested on both affix lists (List 1 and List 2). We used two researcher-generated assessment tasks: 1) affix definition task, and 2) adapted rehit task. Responses were both audio-recorded and transcribed during the assessment by the assessor. The recordings were used to ensure accurate transcription of responses.

Affix Definition Task

The affix definition task was devised by the first, second and third authors and comprised 26 questions. Questions assessed the ability to define the 26 affixes used in the study. Questions were presented in writing using PowerPoint slides on a computer screen and read out loud by the assessor. Each affix was presented to the participant one at a time, and they were asked to define the affix (e.g., "What does the prefix *mis*- mean?"). If participants provided definitions other than those on a list of accepted answers on the response sheet, scaffolding was provided using a pre-set list of spoken and written prompts – three examples of real words containing the affix with accompanying pictures (e.g., "What does *mis*- mean in these words: *misunderstand, mishear, misbehave*?"). All scoring was completed by the fourth author (blind to group allocation) using a written scoring scheme. Two points were awarded for affix definitions that matched one of a pre-determined list of acceptable definitions after the initial question (affix in isolation), one point was awarded for an acceptable definition after scaffolding (affix in real word contexts), half a point was awarded if participants generated real words containing the affix rather than defining it, and zero points were given for an incorrect definition or no response. See Appendix B for a scored excerpt example for the affix definition task.

Adapted Rehit Task

For our second assessment, we adapted the 'Rehit Test' used in Apel et al. (2013). The Rehit Test examines 18 affixes each combined with three different root words in three orally presented steps:

1) Orally blend two morphemes together to create a new nonword (e.g., Tester: "Say *re*-". Participant: "re-". Tester: "Say *hit*". Participant: "hit". Tester: "Now put these two together to make a new silly word". Participant: "rehit".)
2) Define the nonword (e.g., "What do you think *'rehit'* means?"). If the participant gives a response not on the list of acceptable responses (based on pilot-testing conducted with

adults), scaffolding is provided using a pre-set list of prompts (e.g., "Do you think '*rehit'* means *to hit again* or *a person who hits?*")

3) Meaning judgement task with the nonword in a sentence (e.g., "The 'rehit' is on the bed. Does that sentence make sense?"*).*

Our adaptation (the 'adapted rehit task') was designed to evaluate participants' ability to define multimorphemic nonwords (i.e., morphological analysis) and thus used only the second of the three steps from Apel et al.'s (2013) original test. We assessed each of our 26 affixes with only one root word presented in both oral and written modality using a PowerPoint presentation. Participants were presented with each nonword in isolation and then within a sentence (e.g., "I am going to show you some made-up words (they are not real), but they have real meaning parts in them. You need to work out the meaning. For example, if I say *hit* and add *re-* to the beginning, it would be *rehit*, and *rehit* would mean *to hit again*. Let's try some. Work out the meanings of these new words by thinking of the meaning parts. What does *anticlean* mean, as in *I am anticlean*?"). If participants provided a definition not on the list of accepted answers on the response sheet (or if the tester was unsure whether a response was close enough to the intended meaning), a forced choice of two responses were provided using pre-set options (e.g., "Does *anticlean* mean *to clean the wrong way*, or *against being clean*?").

Scoring was completed by the fourth author using a written scoring scheme. Two points were awarded for responses that combined the root and affix meaning (e.g., 'anticlean' = *against being clean)* and one point was awarded for a semantically plausible response (e.g., *unclean)*. Half a point was awarded for selecting the correct definition after the forced choice was given and zero points for selecting the foil from the provided definitions. See Appendix C for a scored excerpt example of our 'adapted rehit task'. Where the fourth author was uncertain how to score a particular response, this was documented and discussed with the first and second authors. The majority decision was then documented and used to inform subsequent scoring decisions.

Inter-Rater Reliability

To evaluate whether the researcher-generated tasks had adequate inter-rater reliability (IRR), 20% of student responses were re-scored independently by the fifth or sixth authors after the project's completion using the same list of acceptable responses available to the original scorer, in addition to the documented decisions regarding unclear responses. IRR was assessed using a two-way mixed, absolute agreement, single-measures intraclass correlation coefficient (ICC; Hallgren, 2012) to establish the degree to which the two independent coders provided consistency in their ratings of children's answers. ICC estimates and their 95% confidence intervals were calculated using SPSS statistical package version 27. The resulting ICC for both tasks was in the excellent range; ICC affix definition = 0.985 (0.982 – 0.988); adapted rehit = 0.985 (0.981 – 0.988). This indicates a high level of agreement across raters and participants, with a minimal amount of measurement error.

Statistical Methods

Four potential predictors were included in our design: time (pre- vs post-intervention), participant group (intervention vs control), task (affix definition vs adapted rehit) and affix group (taught vs untaught). However, it was not possible to analyse all four predictors together because for the control participant group, all affixes were untaught. So, in order to answer our three research questions, we carried out three separate analyses:

- **Research Question 1**: Do the participants in the intervention group make more progress overall with intervention than those in the control group? Here we considered the effects of the predictors of *time* and *participant group* (ignoring any effects of affix group and task).
- **Research Question 2:** Do participants within the intervention group make more progress on taught than untaught affixes? Here we considered the effects of the predictors of *time*, *affix group* and *task* in *just the intervention group*

- **Research Question 3:** Do the participants in the intervention group make more progress than participants in the control group on untaught affixes (i.e., do they show generalisation to untaught affixes)? Here we considered the effects of the predictors of *time*, *task* and *participant group* for *just untaught affixes*.

Where participants in the intervention group missed intervention on particular affixes which they should have been taught, these individual affixes for that participant were marked as "untaught". As stated in the fidelity section, due to absences in the run-up to the national lockdown, several intervention sessions were missed and those in the intervention group therefore received intervention on between 9 and 13 of the 13 affixes in their "taught" list. Therefore, for all analyses considering taught versus untaught affixes, this related to the actual intervention received, rather than the original plan.

For all analyses, we used cumulative linked mixed modelling to account for the ordinal nature of our data. This is a type of general linear model (Howell, 2010) that allows us to mathematically adjust for the variability associated with the individual participants (i.e., multiple responses from the same person are more similar than responses from other people). All analyses were carried out in R version 2024.09.0.375 using the ordinal package (version 2022.11-16). Raw data and R scripts can be accessed at: https://osf.io/5e3g9/?view_only=444d488ae7454cdb92ea4ba55a598d87.

Due to the repeated testing of individual participants, the nesting of participants within SLPs and the nesting of those SLPs within year groups, we compared base models using random intercepts of a nested factor (participant within SLP within year group), with the intercept of participant. There was no difference between these models, so in all other models, we used just participant (without nesting). In all analyses, we used the maximal random effects structure, including intercepts and slopes for both individuals and affixes.

Results

Research Question 1: Do the participants in the intervention group make more progress with intervention than those in the control group?

In order to compare overall progress between the intervention and control groups of participants, we considered performance across both affix groups and both tasks combined at pre- versus post-intervention. A summary of these data is shown in Figure 2. This shows that scores in the control group appear to change very little with time (the number of items receiving '0', '0.5', '1', or '2' shown by the different colour bars is very similar between pre- and post-intervention; the sizes of each colour bar does not appear to change much), whereas for the intervention group, post-intervention more items received a score of '2' (shown by the increase in the size of the yellow bar post-intervention compared with pre-intervention) and fewer received a score of '0' compared with pre-intervention (shown by the decrease in size of the dark blue/purple bar post-intervention when compared with pre-intervention).

We carried out a cumulative linked mixed model (in order to account for the ordinal nature of the data) with the (sum-coded) predictors of time and participant group and random intercepts and slopes for individuals and affixes. The results are shown in Table 5. This shows a significant main effect of time (p<.001) and interaction of participant group and time (p<.001), confirming that the intervention group made significantly more progress than the control group (even though the untaught affixes were included in this analysis).

Research Question 2: Do participants within the intervention group make more progress on taught than untaught affixes?

Figure 3 shows the data for just the intervention group, split by affix group (taught versus untaught), task (adapted rehit versus affix definition) and time (pre- versus post-intervention). This shows little change on untaught affixes (bottom panel). For the taught affixes (top panel) in contrast, the intervention group appeared to show progress (more scores of '2' in yellow bars and

fewer scores of '0' in dark blue/purple bars post-intervention relative to pre-intervention) on both tasks, but particularly on the affix definition task.

To investigate research question 2, we first ran a cumulative link mixed model on just the data from the intervention group with the (sum-coded) predictors of time, task and affix group. Random effects included slopes and intercepts for individual participants and affixes; we also included intercept and slope of number of intervention sessions received. All main effects and interactions (except task x affix group) were significant at $p \leq .001$, including the three-way interaction of time, task and affix group.

In order to unpack this interaction, we re-ran the analysis separately for the two tasks, this time using treatment coding with pre-intervention as the reference level. We ran these models twice, first with the taught affix group as the reference level (shown in Table 6) and then with the untaught affix group as the reference level in order to establish whether each affix group showed significant progress with intervention or not. These analyses showed a significant effect of time on taught affixes for both tasks ($p \leq 001$, see Table 6) but no significant effect of time on untaught affixes for either task ($p = .09$ for adapted rehit and $p = .82$ for affix definition). The interaction between time and affix group was significant for the affix definition task ($p < .001$), but not for the adapted rehit task ($p = .11$).

In order to investigate whether additional diagnoses affected the participants' response to intervention, we added in a fixed factor of diagnosis (DLD versus language disorder associated with another condition). There were no significant effects or interactions involving diagnosis (for all interactions involving both diagnosis and time, $p > .29$). Model comparisons showed that the model including diagnosis was not significantly different from the model excluding diagnosis for either adapted rehit ($p = .36$) or affix definition ($p = .14$). Therefore, it seems there was no effect on response to intervention according to whether participants met the criteria for DLD or language disorder associated with another condition.

Research Question 3: Do the participants in the intervention group make more progress on untaught affixes than participants in the control group (i.e., do they show generalisation to untaught affixes)?

The data for just the untaught affixes are shown in Figure 4. This shows very similar patterns pre and post-intervention in both the intervention and control groups (coloured bars show little change in size between pre- and post-intervention). We ran a cumulative link mixed model with the (sum-coded) predictors of time, task and group with pre-intervention and the control group as the reference levels (and random intercepts and slopes for individual participants and affixes). The results (in Table 7) showed a main effect of task (p<.001), where affix definition scores were poorer than those on the adapted rehit task. No other main effects or interactions were significant. Thus, the intervention group did not differ from the control group on untaught affixes.

Discussion

This study aimed to investigate firstly whether participants with (D)LD receiving morphological awareness and analysis intervention made more progress than those in the control group. Then we investigated whether participants in the intervention group made more progress on taught than untaught affixes in their ability to define affixes and/or to infer the meaning of novel words containing those affixes. Finally, we investigated whether participants in the intervention group made more progress on untaught affixes than participants in the control group (i.e., whether those in the intervention group showed generalisation to untaught affixes).

Our first research question considered overall progress on the researcher-developed morphological tasks in the intervention versus control group following a mean of around seven hours of paired intervention with an SLP focused on morphological awareness and analysis with a group of taught affixes. We found that the intervention group made significantly more progress overall than the control group (shown by a significant interaction between participant group and time, p<.001). This finding is remarkable because all 26 affixes were included, but the participants

in the intervention group only received intervention on between nine and thirteen of these 26 affixes. Our findings therefore add to the currently very limited evidence showing that children with identified language difficulties can make significant progress with morphological intervention (Good et al., 2015; Katz & Carlisle, 2009; McLeod & Apel, 2015). Our study also confirms the findings of studies with other groups of children that this type of intervention holds promise for improving vocabulary skills (Apel et al., 2013; Apel & Diehm, 2014; Baumann et al., 2003; 2002; Bowers et al., 2010; Carlisle, 2010; Goodwin & Ahn, 2013; Reed, 2008).

Our second and third research questions primarily investigated generalisation. We found that the participants in the intervention group improved both on their ability to define the affixes (affix definition task) and to generalise their knowledge of these affixes to work out the meaning of new words containing those affixes (adapted rehit task). This finding is similar to previous studies with typically developing children (Apel & Diehm, 2014; Baumann et al., 2003; 2002), children with language weaknesses including those where the language of instruction was their second language (Gellert et al., 2021) and children with identified language difficulties (Good et al., 2015). However, we found no generalisation to untaught affixes; the intervention group showed no significant progress following intervention on the untaught affixes and the change in performance with time on untaught affixes was no different in the intervention and control groups. This is in line with previous studies of vocabulary intervention in children with DLD, which have focused primarily on teaching vocabulary at a whole word level (with a focus on their semantics and phonology) and have shown low generalisation to untaught words (e.g., Joffe et al., 2019; Lowe et al., 2019; Wright et al., 2018). This lack of generalization to untaught words or affixes indicates that children with (D)LD need to be taught individual affix meanings as they do not just learn through exposure or repeated testing, even when their morphological awareness has been raised through intervention focusing on other affixes. However, our finding of generalisation in terms of working out the meanings of other words containing taught affixes (on the adapted rehit task) is important as this indicates that learning the meanings of affixes could potentially unlock the

meanings of a wide range of words containing these affixes. As it is not possible to teach all the words that a young person needs to know, teaching them strategies and skills in the area of morphological awareness and analysis, combined with teaching of the meaning of individual affixes, has the potential to greatly enhance the number of words they can understand.

Limitations and Future Directions

We had planned to continue the study for an additional term, providing the intervention to the waiting control group and carrying out further testing after this to establish whether the waiting controls also made similar progress, and for the initial intervention group, whether any effects of intervention were maintained. Unfortunately, the study was cut short by the COVID-19 pandemic and related school closures. Therefore, unfortunately we cannot comment on whether progress was maintained in the intervention group, whether it would have been replicated in the waiting control group or whether there was any generalisation to the Word Derivations subtest.

Our intervention included many components, so it is difficult to know which were active ingredients. We also did not control within-session dosage or take recordings of the intervention sessions, so the number of times each potential active ingredient was used during sessions and fidelity to the treatment protocol is unknown. With respect to the assessment tasks, both tasks involved defining either an affix or a new word consisting of an affix and root. This is particularly difficult for children with severe language disorders and therefore could have masked some of their progress with intervention. However, despite this, we showed significant differences in progress between the intervention and control groups. Our study was not pre-registered. Future studies could aim to address these limitations by being pre-registered and by controlling for dosage and active ingredients, including a receptive only task and carrying out maintenance testing.

Conclusions

Explicit teaching of the meaning of affixes and how to combine them with root words to make new meanings led to progress both in the ability of young people with (D)LD to define those affixes and in their ability to work out the meaning of new words containing those affixes. Thus, the benefits of the intervention go beyond the item-specific learning seen in many other studies of vocabulary interventions for children and young people with DLD. Thus, including a focus on morphological awareness and analysis with affixes has the potential to greatly increase understanding of vocabulary in this group of young people following relatively small amounts of intervention.

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CONSORT checklist: see Supplementary information 9

CONSERVE checklist: see Supplementary information 10

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Appendices

Appendix A

Participant data for participants in the intervention and control groups

Group	Child	Sex	DLD vs LD (ASD) vs LD (genetic)	Age (months)	CELF-4* Core Lang (SS)	CELF-4 Receptive (SS)	CELF-4 Expressive (SS)	BPVS** (SS)	WRAT Reading (SS)	TOAL-4 Word derivations subtest (SCS)
Intervention	1	F	LD (genetic)	165	40	52	45	72[3]	68	3
	2	M	DLD	168	44	58	47	<70[3]	65	5
	3	M	LD (ASD)	165	44	61	47	<70[3]	78	4
	4	M	LD (ASD)	168	54	70	51	<70[3]	69	5
	6	M	DLD	161	60	79	51	70[3]	74	6
	7	M	DLD	169	51	63	52	76[2]	55	4
	8	M	LD (ASD)	167	58	67	61	<70[3]	114	6
	9	M	DLD	181	59	63	47	75[2]	65	5
	10	F	LD (genetic)	181	52	54	61	57[2]	88	4
	11	F	DLD	179	58	56	59	86[2]	75	6
	12	M	DLD	182	69	81	67	81[2]	111	5
Control	13	M	DLD	179	40	50	45	66[2]	70	6
	14	M	DLD	176	48	64	51	71[2]	65	3
	15	M	DLD	165	42	55	45	<70[3]	56	5
	16	M	DLD	168	44	55	53	72[3]	75	4
	17	M	DLD	161	50	67	47	78[3]	62	6
	18	M	DLD	171	54	61	53	72[3]	69	3
	19	M	DLD	164	42	52	49	76[3]	72	6
	20	F	DLD	163	42	50	47	<70[3]	74	5
	21	F	LD (genetic)	169	66	79	65	<70[3]	94	7
	22	M	DLD	168	50	61	53	<70[3]	67	6
	23	M	DLD	179	44	64	45	70[2]	78	6
	24	M	DLD	160	64	64	65	71[2]	74	6
	25	F	DLD	181	58	61	63	76[2]	79	8
	26	M	LD (genetic)	161	81	81	80	<70[3]	114	7

Key: F: Female, M: Male. SS – Standard Scores, SCS – Scaled Scores. Subtest scaled scores have a mean of 7 and a standard deviation of 3.

*Participants 7 and 9 were assessed on the Clinical Evaluation of Language Fundamentals (CELF)-5 (Wiig, Semel & Secord, 2017), while all other

participants were assessed on the CELF-4 (Semel, Wiig & Secord, 2003). **Participants marked [2] were assessed with the British Picture Vocabulary Scale 2nd Edition (BPVS-2, Dunn, Dunn & Styles, 1997). Those marked with [3] were tested on the BPVS 3rd Edition (BPVS-3, 2009).

Appendix B

Example completed score sheet excerpt for affix definition task

- If initial response is not in the list of correct responses, repeat the question with examples and pictures
- Score the best response/allocate points to the highest scored response for each question
- Scoring guideline:
  - 2 = accurate response from the list of responses provided
  - 1 = accurate response after examples provided
  - 0.5 = generates own examples of words, but does not define the affix
  - 0 = incorrect definition or defines/repeats one of the example words

1. What does **un**- mean? "reversing, going back"

not / reverse / do the opposite /the opposite of	(2)			
own examples (undo, unfold or untie accepted *if* given before prompts)			0.5	
under / no response				0

With examples and images

not / reverse / do the opposite /the opposite of		1		
defines one/ more words or chooses one/ more words / no response				0

2. What does **uni-** mean? "you can put it in units"

One	2			
own examples (uniform, unicorn or unicycle accepted *if* given before prompts)			0.5	
no response				(0)

With examples and images

One		1		
defines one/ more words or chooses one/ more words / no response				0

3. What does -**graph** mean? "photograph"

Picture / image/ photo/ text/ writing	2			
own examples e.g., paragraph (autograph, photograph or graphic accepted *if* given before prompts)			(0.5)	
drawing / writing / something printed / no response				0

With examples and images

Picture / image/ photo		1		
defines one/ more words or chooses one/ more words / no response				0

Note: Participant responses in " ".

Appendix C

Example completed score sheet excerpt for adapted rehit task

18. **Electripen:** "an electricity pen"

An electric pen / electrical pen / pen with electricity / pen that makes electricity	(2)			
Charged pen		1		
Uses electric / pen that goes / no response				0

With forced choices

a) A water pen				0
b) An electric pen			0.5	

19. **Monotrip**: "a trip"

One trip / single trip / one way trip	2			
A trip / trip over once / trip somewhere		(1)		
no response				0

With forced choices

a. One trip			0.5	
b. Lots of trips				0

19. **Scarograph**: "something scary"

Picture of something scary / scary picture / scary photo (+ any synonym of scary) / scary image / graph of how scared someone was / writing about something scary	2			
Sound of something scary / no response				0

With forced choices

a. A sound of something scary				0
b. A picture of something scary			(0.5)	

20. **Stuckable**: "something sticky"

Can stick / can get stuck / can be stuck / able to be stuck	2			
Stuck / sticking / it will not move/ can't get it off/ stuck together / no response				0

With forced choices

a) Something that can get stuck			0.5	
b) Something that can't get stuck				(0)

Note. **Participant responses in " ".**

Tables

Table 1

Pre-intervention scores on standardised tests, overall and in the two groups

	Overall n = 25		Intervention group n = 11		Control group n = 14		*p* value
Males:Females	18:7		7:4		11:3		
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	
Age	14;02 (0;07)	13;04-15;02	14;03 (0;07)	13;04-15:02	14;01 (0;07)	13;04-15:01	0.41
CELF-4/5[a] Receptive Language Standard Score	62.8 (9.4)	50-81	64.0 (9.6)	52-81	61.7 (9.5)	50-81	0.56
CELF-4/5 [a] Expressive Language Standard Score	54.0 (8.9)	45-80	53.5 (7.3)	45-67	54.4 (10.3)	45-80	0.80
CELF-4/5 [a] Core Language Standard Score	52.6 (10.3)	40-81	53.5 (8.1)	40-69	51.8 (11.8)	40-81	0.67
BPVS-III/II [b] Standard Score [c]	n/a	57-86	n/a	57-86	n/a	66-78	n/a
BPVS-III/II [b] Raw Score	101.1 (11)	77-119	99.6 (14.1)	77-119	102.3 (8.1)	89 - 116	0.59
WRAT 5 Word Reading Standard Score	76.4 (16.2)	55-114	78.4 (18.9)	55-114	74.9 (14.3)	56-114	0.62
TOAL-4 Word Derivational subtest scaled score	5.2 (1.3)	3-8	4.8 (1.0)	3-6	5.6 (1.5)	3-8	0.14

[a] Participants 7 and 9 were assessed on the CELF-5 (Wiig, Semel & Secord, 2017), while all other participants were assessed on the CELF-4 (Semel, Wiig & Secord, 2003),

[b] five participants from each group were assessed using the BPVS 2nd Edition (BPVS-2, Dunn, Dunn & Styles, 1997), while the remaining students were tested on the BPVS 3rd Edition (BPVS-3, 2009),

[c] BPVS mean standard scores were not calculated, as several of the students scored at floor (70) on the BPVS-3 (intervention group N=4, controls N=5) but the floor is lower (40) on the BPVS-2, thus a mean involving both tests is meaningless.

Probability note. P-values compare the scores of the two groups on t-tests

Table 2

Grouped intervention affixes

List 1	List 2
re-, de-, dis-, anti-	un-, mis-, in-
-er, -able	-ful, -less
centi-, milli-, uni-	bi-, tri-, mono-, multi-
aer/aero-, audi -	electr-, -graph
hydr/hydro-	aqua-
super-	sub-

Table 3

Order of intervention

	List 1		List 2	
Session	**Affixes**	**Meaning**	**Affixes**	**Meaning**
1. Introductory session				
2. Prefix teaching	re- (rebuilt, recycled)	again	un- (unafraid, uncertain)	not
3. Prefix teaching	de- (decompose, dehydrated)	take away/ remove/ reverse	mis- (misguide, mistrust)	bad/wrong
4. Prefix teaching	dis- (disorganised, disagreed)	not/opposite/ reverse	in- (indecisive, incorrect)	not
5. Review	**re-, de-, dis-**		**un-, mis-, in-**	
6. Suffix teaching	-er (writer, farmer)	maker/doer of	-ful (grateful, helpful)	lots of
7. Suffix teaching	-able (predictable, understandable)	able to	-less (fearless, toothless)	without
8. Review	**-er, -able**		**-ful, -less**	
9. Prefix teaching	centi (centipede, centimetres)	100/one hundredth	bi- (bicycle, bilingual)	two
10. Prefix teaching	milli- (millepede, millimetres)	1000/one thousandth	tri- (triangles, tricycle)	three
11. Prefix teaching	uni- (uniform, unicycle)	one	mono- (monocle, monologue)	one
12. **List 1: Review** List 2: Prefix teaching	**centi-, milli-, uni-**		multi- (multicultural, multilingual)	p many/lots of
13. List 1: Prefix teaching **List 2: Review**	anti- (antibacterial, antiseptic)	against	**bi-, tri-, mono-, multi-**	
14. Prefix teaching	aer/aero- (aerosol, aerobics)	air	electr- (electronic, electrocuted)	electricity
15. Prefix/suffix teaching	audi– (audiologist, audiobook)	hearing	-graph (autograph, photograph)	writing
16. Prefix teaching	hydr/hydro- (hydrotherapy, hydrated)	water	aqua– (aquarium, aqualung)	water
17. Prefix teaching	super- (superman, superstar)	more/better/ higher	sub- (subway, submarine)	below/under
18. Review	**anti-, aero-, audi-, hydro-, super-**		**electr-, graph, aqua-, sub-**	

Table 4

Morphemes Matter intervention principles

Intervention principle	Explanation and references
1. Explicit instruction	The intervention is designed to align with Barak Rosenshine's (2012) principles of explicit instruction, with a particular focus on: 1) beginning each session with a short review of previous learning, 2) presenting new material in small steps with student practice after each step, 3) asking a large number of questions throughout the session, 4) providing models and examples, 5) guiding student practice, 6) checking for understanding, 7) obtaining a high success rate, and 8) providing scaffolds for difficult tasks.
2. Gradual release of responsibility	Using a gradual release of responsibility (Fisher & Frey, 2021), intervention tasks are initially completed by the SLP using modelling (commonly called 'I Do'), followed by joint completion of the tasks with the SLP and participants working together ('We Do'), and finally tasks are completed independently by participants ('You Do'). Explicit feedback and scaffolding is provided throughout this gradual release.
3. Multimodal approach	The intervention incorporates a multimodal approach which includes saying, hearing, reading and writing affixes and their meanings combined with using images and gestures when learning the affixes and their definitions. Multimodal approaches have been shown to promote language learning by offering an additional representational form (Goldin-Meadow, 2014).
4. Direct, 'rich' affix instruction	We utilised a direct, explicit, 'rich' vocabulary instructional approach (Beck et al., 2008) including: defining affixes using student-friendly definitions, presenting affixes in a variety of meaningful contexts, and supporting deep processing of affix meanings through comparison, description, and use within sentences. Spaced retrieval practice is included at the beginning of each session where (where participants have to retrieve and produce targets repeatedly with other intervening material, Leonard et al., 2021). A significant amount of practice in applying the affixes in words, sentences and short stories is also included to enhance word learning (Haebig et al., 2019; Karpicke & Bauernschmidt, 2011; Karpicke & Roediger III, 2008).

Table 5

Results of cumulative linked mixed model of time x participant group (across both affix groups and tasks)

		time x group	
Predictors	*Odds Ratios*	*CI*	*p*
participant group	1.13	0.60 – 2.12	0.715
Time	1.70	1.41 – 2.05	**<0.001**
participant group × time	2.24	1.54 – 3.24	**<0.001**
Random Effects			
σ^2	3.29		
$\tau_{00\ affix}$	0.56		
$\tau_{00\ ID}$	0.45		
$\tau_{11\ affix.timepost\text{-}intervention}$	0.00		
$\tau_{11\ ID.timepost\text{-}intervention}$	0.07		
$\rho_{01\ affix}$	-1.00		
$\rho_{01\ ID}$	0.80		
ICC	0.23		
N_{affix}	26		
N_{ID}	25		
Observations	2600		
Marginal R^2 / Conditional R^2	0.023 / 0.252		

Table 6

Results of cumulative link mixed model of affix group (taught vs untaught) and time for the intervention group only, split by task

	adapted rehit			**affix definition**		
Predictors	*Odds Ratios*	*CI*	*p*	*Odds Ratios*	*CI*	*p*
affix group [untaught]	0.51	0.32 – 0.82	**0.005**	0.88	0.51 – 1.51	0.635
time [post-intervention]	2.56	1.51 – 4.34	**0.001**	19.46	9.13 – 41.49	**<0.001**
affix group [untaught] × time [post-intervention]	0.58	0.30 – 1.12	0.106	0.06	0.02 – 0.13	**<0.001**
Random Effects						
σ^2	3.29			3.29		
τ_{00}	1.02 $_{affix}$			1.24 $_{affix}$		
	0.48 $_{ID}$			0.42 $_{ID}$		
	0.21 $_{num\_sessions}$			0.05 $_{num\_sessions}$		
τ_{11}	0.04 $_{affix.timepost\text{-}intervention}$			0.07 $_{affix.timepost\text{-}intervention}$		
	0.02 $_{ID.timepost\text{-}intervention}$			0.20 $_{ID.timepost\text{-}intervention}$		
	0.02 $_{num\_sessions.timepost\text{-}intervention}$			0.09 $_{num\_sessions.timepost\text{-}intervention}$		
ρ_{01}	-1.00 $_{affix}$			1.00 $_{affix}$		
	1.00 $_{ID}$			0.89 $_{ID}$		
	1.00 $_{num\_sessions}$			1.00 $_{num\_sessions}$		
ICC	0.34			0.43		
N	26 $_{affix}$			26 $_{affix}$		
	11 $_{ID}$			11 $_{ID}$		
	4 $_{num\_sessions}$			4 $_{num\_sessions}$		
Observations	572			572		
Marginal R^2 / Conditional R^2	0.064 / 0.382			0.217 / 0.556		

Note. All predictors are treatment coded and the reference level is taught affixes pre-intervention.

Table 7

Results of cumulative link mixed model of task (affix definition vs adapted rehit) x time x participant group for untaught affixes only

		Score	
Predictors	*Odds Ratios*	*CI*	*p*
task	0.31	0.26 – 0.38	**<0.001**
time	1.24	0.98 – 1.55	0.070
participant group	0.66	0.32 – 1.36	0.261
task × time	0.95	0.64 – 1.39	0.774
task × participant group	0.90	0.61 – 1.32	0.591
time × participant group	1.12	0.71 – 1.77	0.618
(task × time) × participant group	0.74	0.35 – 1.59	0.442
Random Effects			
σ^2	3.29		
$\tau_{00\ affix}$	0.71		
$\tau_{00\ ID}$	0.57		
$\tau_{11\ affix.timepost\text{-}intervention}$	0.00		
$\tau_{11\ ID.timepost\text{-}intervention}$	0.09		
$\rho_{01\ affix}$	1.00		
$\rho_{01\ ID}$	0.74		
ICC	0.28		
N_{ID}	25		
N_{affix}	26		
Observations	2087		
Marginal R^2 / Conditional R^2	0.075 / 0.333		

Note. All predictors are sum-coded.

Figures

Figure 1:

CONSORT diagram showing the flow of participants through the randomised control trial

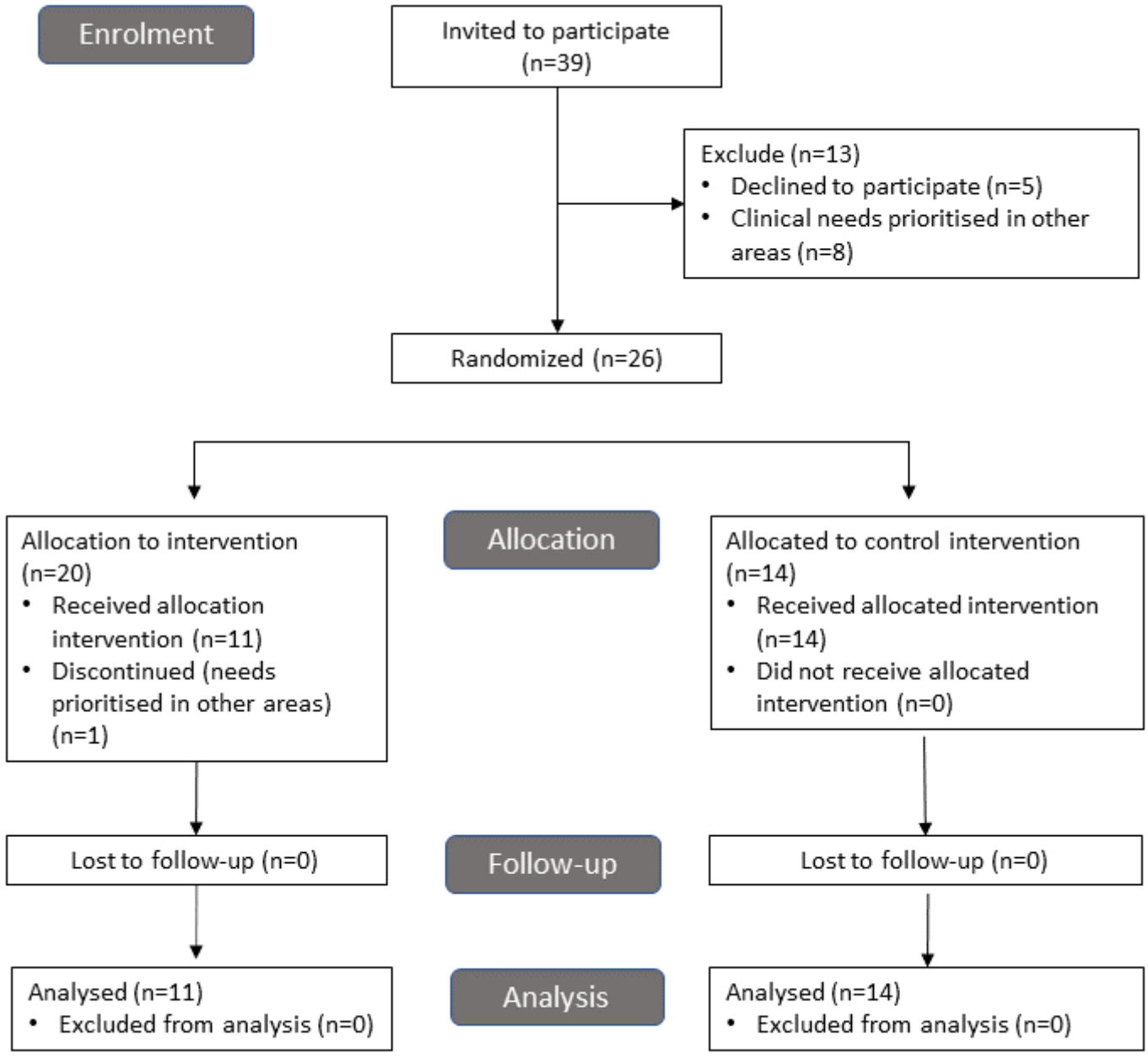


Figure 2

Number of responses receiving each score split by time and participant group across both affix groups and tasks (total number of responses is lower for the intervention group as this participant group contained fewer participants)

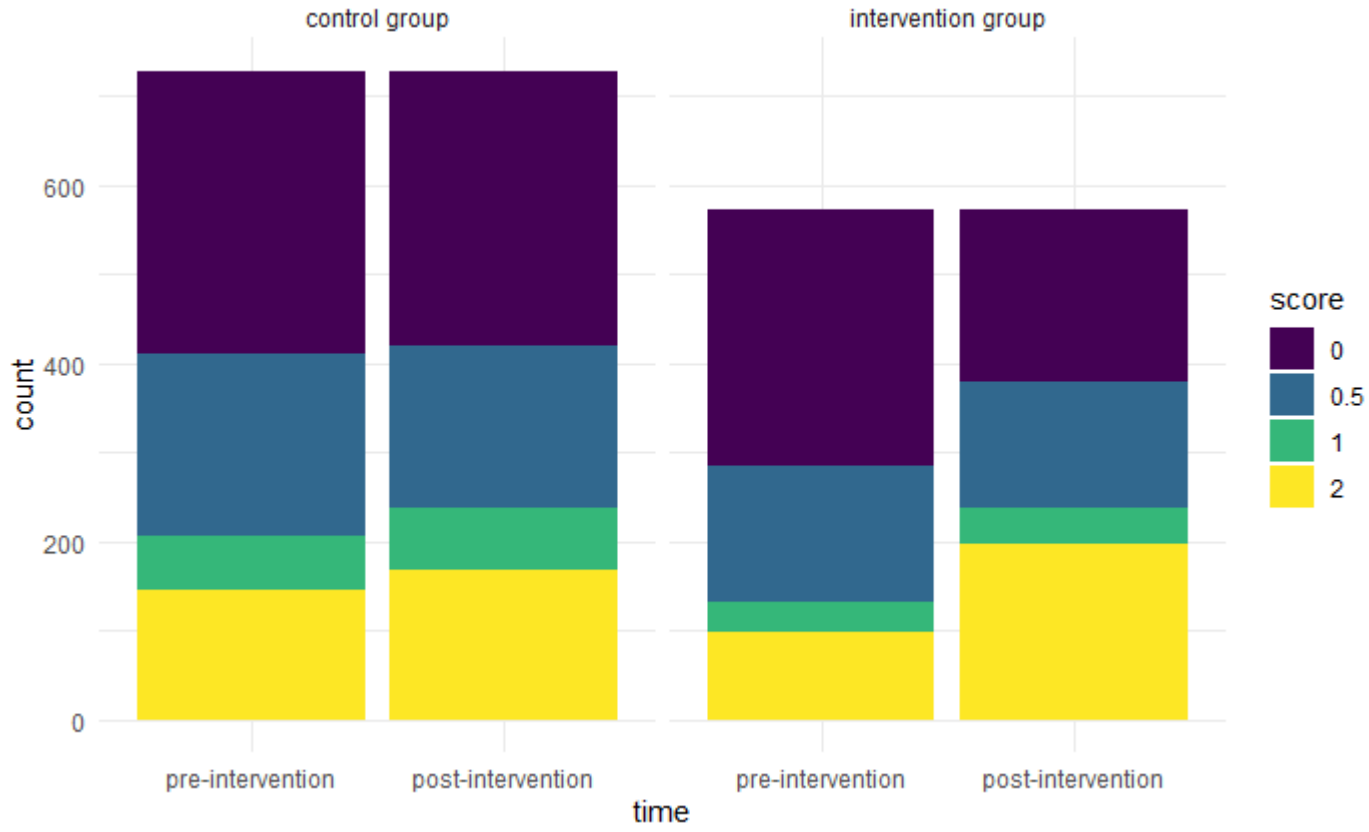


Figure 3:

Number of responses receiving each score split by task, affix group (taught vs untaught) and time for intervention group only

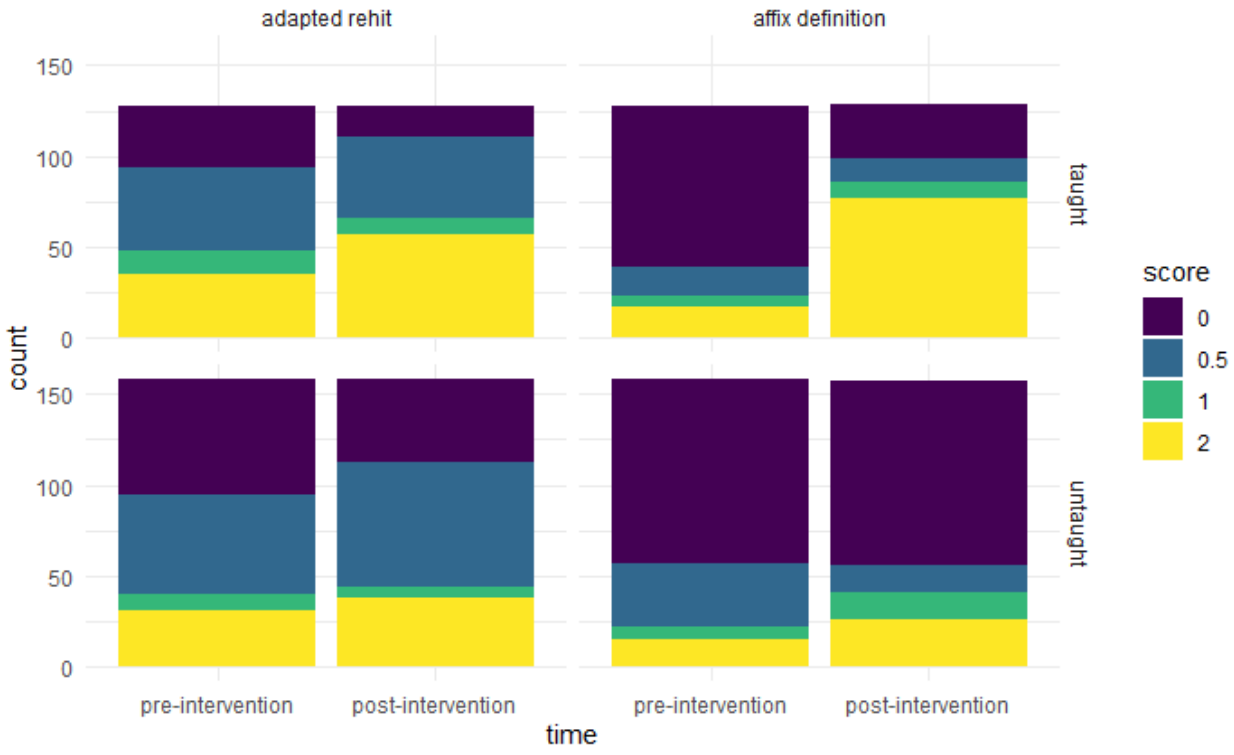


Figure 4

Number of responses receiving each score split by time and group across both tasks for untaught affixes only (total number of responses is lower for the intervention group as this group contained fewer participants)

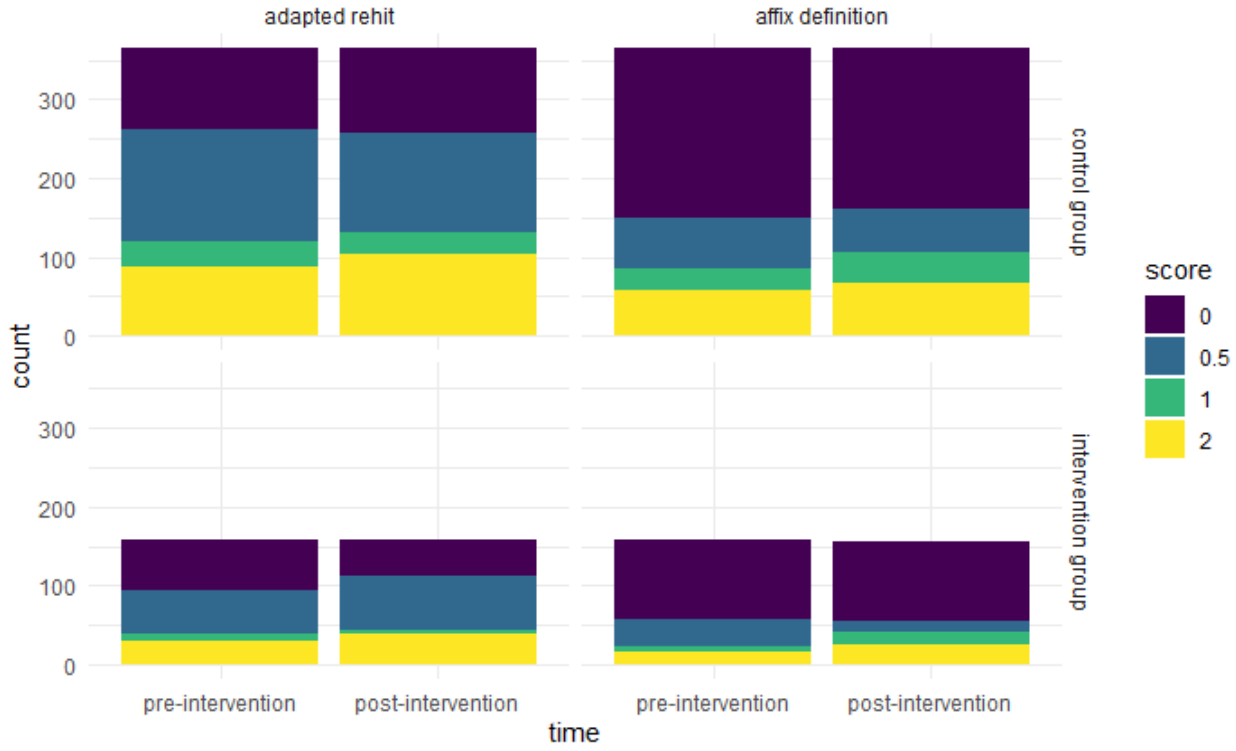


Figure captions

Figure 1

CONSORT diagram showing the flow of participants through the randomised control trial.

Figure 2

Number of responses receiving each score split by time and participant group across both affix groups and tasks (total number of responses is lower for the intervention group as this participant group contained fewer participants)

Figure 3

Number of responses receiving each score split by task, affix group (taught vs untaught) and time for intervention group only.

Figure 4

Number of responses receiving each score split by time and group across both tasks for untaught affixes only (total number of responses is lower for the intervention group as this group contained fewer participants)

Supplementary information

Supplementary Information 1

Template for Intervention Description and Replication (TIDieR) Checklist for 'Morphemes Matter'

Item	Description
1. Brief name	Morphemes Matter
2. Why	The aim of Morphemes Matter is to improve understanding of affixes in adolescents with language disorder in order to support vocabulary development. Children with developmental language disorder (DLD) show difficulties learning and retaining new words. Previous studies have proven effective in teaching new words to students with DLD of various ages (e.g., Ebbels et al., 2022; Joffe et al., 2019; Lowe et al., 2019; Wright et al., 2018). However, the number of words learned is often low, with little or no evidence of generalisation to untaught words. By training children to break down words and recognise the meaning of common affixes, it is hoped this will support their understanding and use of a wider range of words. While typically developing children build morphological awareness gradually across childhood through conversation and written exposure, those with DLD may require more explicit instruction to recognise and process morphological units within words. Previous studies have investigated the effects of morphological instruction on literacy with both typically developing and language impaired children (e.g., Bowers et al., 2010; Carlisle, 2010; Kirk & Gillon, 2009; Wolter & Dilworth, 2014). However, none have focused specifically on vocabulary outcomes for secondary-aged children with language disorder. Morphology Matters has been developed specifically for this population, aiming to increase morphological awareness by focusing on segmenting and blending prefixes, roots and suffixes; explicit instruction of meanings of individual affixes and combining the meaning of known roots and taught affixes to work out the meanings of multi-morphemic words.
3. What (materials)	Each session is accompanied by a session plan, to guide the speech-language pathologist (SLP), outlining specific goals and activities for the session. Handouts and worksheets are designed to use within each session. Additional scripted student friendly definitions and gestural cues are provided for each affix, to support student's understanding and learning. The programme targets 21 prefixes and five suffixes, selected with reference to previous publications (e.g., Apel et al., 2013, Baumann et al., 2022, Goodwin et al., 2012 and Zoski et al. 2018) and in consultation

	with secondary school mathematics and science teachers. Affixes are grouped into semantically related groups (e.g., number: milli-, cent-, tri-, bi-) as suggested by Baumann et al. (2002) and Goodwin et al. (2012). For the purposes of our research study, these groups of affixes were split into two lists, with similar numbers of affixes from each semantically related group. Students were assigned to work through one of these two lists: **List 1**: re-, de-, dis-, anti-; -er, -able; centi-, milli-, uni-; aer/aero-, audi-; hydr/hydro-; super- **List 2**: un-, mis-, in-; -ful, -less; bi-, tri-, mono-, multi; electr-, -graph; aqua-; sub-
4. What (procedures)	The intervention includes one introductory session, 14 teaching sessions and five review sessions. A review session is delivered after all affixes in a particular semantic group have been taught. In the introductory session, participants are introduced to the purpose of the intervention and taught the meaning of the concepts 'prefix', 'suffix' and 'root', using an explicit teaching poster (see Supplementary Information 1). Following this initial teaching, the SLP presents visuals for all target affixes in the participants' intervention list. Each visual has a picture, the written affix and a simple definition (see Supplementary Information 2). Using modelling, imitation and retrieval practice, the SLP and participants name and define each affix in their list. Pre-determined gestures for each affix are used during this explicit teaching phase to act as an additional 'cognitive hook' to support learning and retrieval of affix meanings. The final task in the introductory session involves students completing a morpheme blending activity which includes a printed root word in the middle of a page with blank squares in the prefix and suffix positions. Using a pile of printed cards containing written prefixes or suffixes, the SLP and participants take turns to add affixes to the given root and generate as many real words as they can. These words are then written on the page. The main intervention sessions follow the structure below: • The SLP shares the learning intention and success criteria for the session. They then review (reteach) and the students retrieve the meaning of 'prefix', 'suffix', and 'root' using the explicit teaching poster (Supplementary Information 2). • The SLP and student say, read and gesture all intervention and basic set affixes and their definitions (Supplementary Information 3). • Explicit teaching of target affix for the session using a student friendly definition, gesture and picture, with modelling, imitation, repetition and retrieval practice.

	• SLP and participants fill in an affix mat for the target affix. The affix mat is a graphic organiser that includes the target affix in the middle of the page and boxes around the page with space for the participant and SLP to write a definition of the affix, example words using the affix and a sentence containing one of the words. • Complete morpheme study table (see Supplementary Information 4). The morpheme table is a graphic organiser that includes four words containing the target affix. Using a gradual release of responsibility, SLP and participants identify the prefixes, suffixes and roots and their meanings in each word, define the words and discuss how each affix contributes to the meaning, use the words in sentences, and draw pictures to depict their meaning. • Complete reading passage (see Supplementary Information 5) using a passage containing multiple examples of the target affix. Participants are supported to identify words containing the target affix in the passage and discuss the overall meaning of each word, in relation to the individual meanings of the morphemes. • Participants and SLP complete a reflection sheet (see Supplementary Information 6) to summarise learning from the session and promote generalisation - writing what the affix is, its meaning and when they might use it outside of the session. For the review sessions, the meanings of previously taught affixes within that semantic group are revisited and participants complete a review sheet (see Supplementary Information 8). These review sheets include affix to definition matching, cloze sentences, and generating and defining words containing taught affixes.
5. Who provides	Morphemes Matter is designed to be delivered by qualified SLPs who are experienced in working with this population. Within the current study, sessions were carried out by the students' usual SLP, who were familiar with their strengths and individual support needs. Delivering SLPs received one hour of training, demonstrating the intervention, as well as written resources with background information and example scripted lessons to support their understanding of the programme.
6. How	The intervention is delivered face to face with pairs of children with DLD, aged between 13 and 15 years. Both participants are present at all intervention sessions.
7. Where	Sessions are delivered in a quiet room at the child's school.

8. When and how much

The intervention takes place twice a week for 30 minutes and is designed to be delivered over 9 weeks. The table below, provides an overview of the structure of the programme.

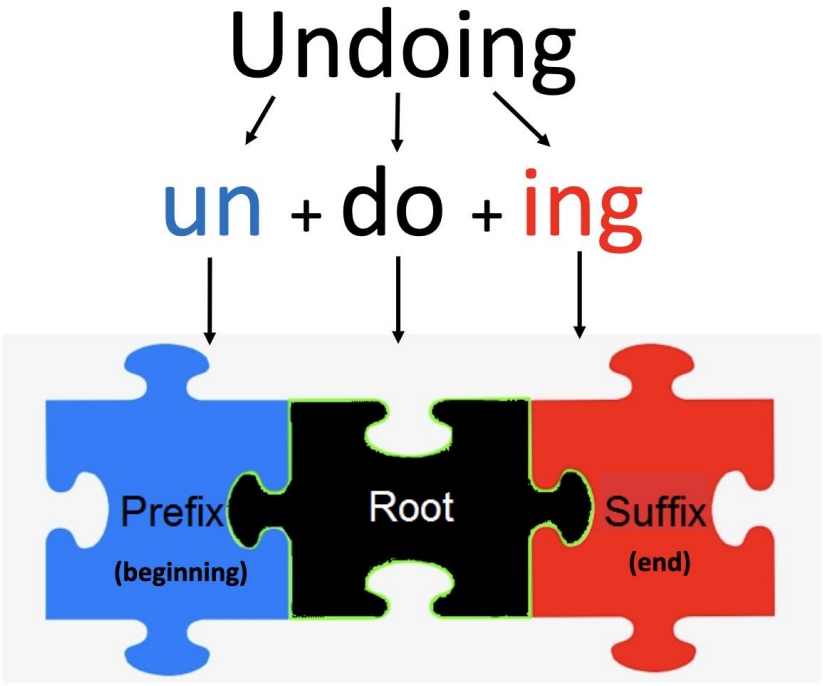
	List 1		List 2	
Session	**Affixes**	**Meaning**	**Affixes**	**Meaning**
Introductory session				
1. Prefix teaching	re- (rebuilt, recycled)	again	un- (unafraid, uncertain)	not
2. Prefix teaching	de- (decompose, dehydrated)	take away/ remove/ reverse	mis- (misguide, mistrust)	bad/wrong
3. Prefix teaching	dis- (disorganised, disagreed)	not/opposite/ reverse	in- (indecisive, incorrect)	not
4. Review	**re-, de-, dis-**		**un-, mis-, in-**	
5. Suffix teaching	-er (writer, farmer)	maker/doer of	-ful (grateful, helpful)	lots of
6. Suffix teaching	-able (predictable, understandable)	able to	-less (fearless, toothless)	without
7. Review	**-er, -able**		**-ful, -less**	
8. Prefix teaching	centi (centipede, centimetres)	100/one hundredth	bi- (bicycle, bilingual)	two
9. Prefix teaching	milli- (millepede, millimetres)	1000/one thousandth	tri- (triangles, tricycle)	three
10. Prefix teaching	uni- (uniform, unicycle)	one	mono- (monocle, monologue)	one
11. **List 1: Review** List 2: Prefix teaching	**centi-, milli-, uni-**		multi- (multicultural, multilingual)	many/lots of
12. List 1: Prefix teaching **List 2: Review**	anti- (antibacterial, antiseptic)	against		
			bi-, tri-, mono-, multi-	
13. Prefix teaching	aer/aero- (aerosol, aerobics)	air	electr- (electronic, electrocuted)	electricity
14. Prefix/suffix teaching	audi– (audiologist, audiobook)	hearing	-graph (autograph, photograph)	writing
15. Prefix teaching	hydr/hydro- (hydrotherapy, hydrated)	water	aqua– (aquarium, aqualung)	water

	16. Prefix teaching	super- (superman, superstar)	more/better/ higher	sub- (subway, submarine)	below/under
	17. Review	**anti-, aero-, audi-, hydro-, super-**		**electr-, graph, aqua-, sub-**	

9. Tailoring	A 'gradual release of responsibility' (Fisher & Frey, 2021), is core to 'Morphology Matters'. Intervention tasks are initially completed by the SLP using modelling (commonly called 'I Do'), followed by joint completion of the tasks with the SLP and participants working together ('We Do'), and finally tasks were completed independently by participants ('You Do'). The pace of transition between stages is guided by participants' individual responses. Explicit, individualised feedback and scaffolding are provided throughout this gradual release. Following Rosenshine's (2012) principles of explicit instruction, SLPs regularly check students' understanding, where needed, offer additional support (including multimodal prompts) for students to achieve success within intervention tasks.
10. Modifications	The Morphology Matters programme was originally designed to be delivered over nine weeks, as outlined above. Due to the Covid-19 pandemic, our initial trial of the intervention was cut short, such that the students only received eight weeks of the intended nine. While these students still made significant progress in response to the intervention, we would still recommend that SLPs aim for the full 18 sessions to maximise students' progress across the targeted morphemes.
11. How well	Within the programme, attendance and intervention fidelity was assessed using a checklist, which was completed by the delivering SLP at the end of each session. SLPs were asked to report any deviation from the session plan. When participants were unable to attend a session, SLP discretion was used to adapt the intervention plan, by either combining activities for two affixes into one session or leaving out that session. For the current study, participants attended an average of 14.3 of the planned 18 intervention sessions (range: 12-15). Reduced attendance rates were mainly due to school closure related to the COVID-19 pandemic which led to the post-intervention assessment being brought forward. Attendance was also affected by staff and student absences in the weeks leading up to the national lockdown in the U.K. In the last two to three weeks, when either students or the SLP had been absent, two affixes in adjacent sessions were taught together in the following session to try to cover all affixes. To achieve this, the first author worked with each SLP to adapt these sessions - most often by reducing the number of words taught for each affix and/or omitting the reading comprehension task from the session. This attempt to cover all affixes was partially successful: four participants received some intervention for all 13 affixes, four participants received intervention for 12 affixes, one participant for 10 affixes and two participants for only nine affixes. The final review session was not completed for nine out of 11 of the participants.

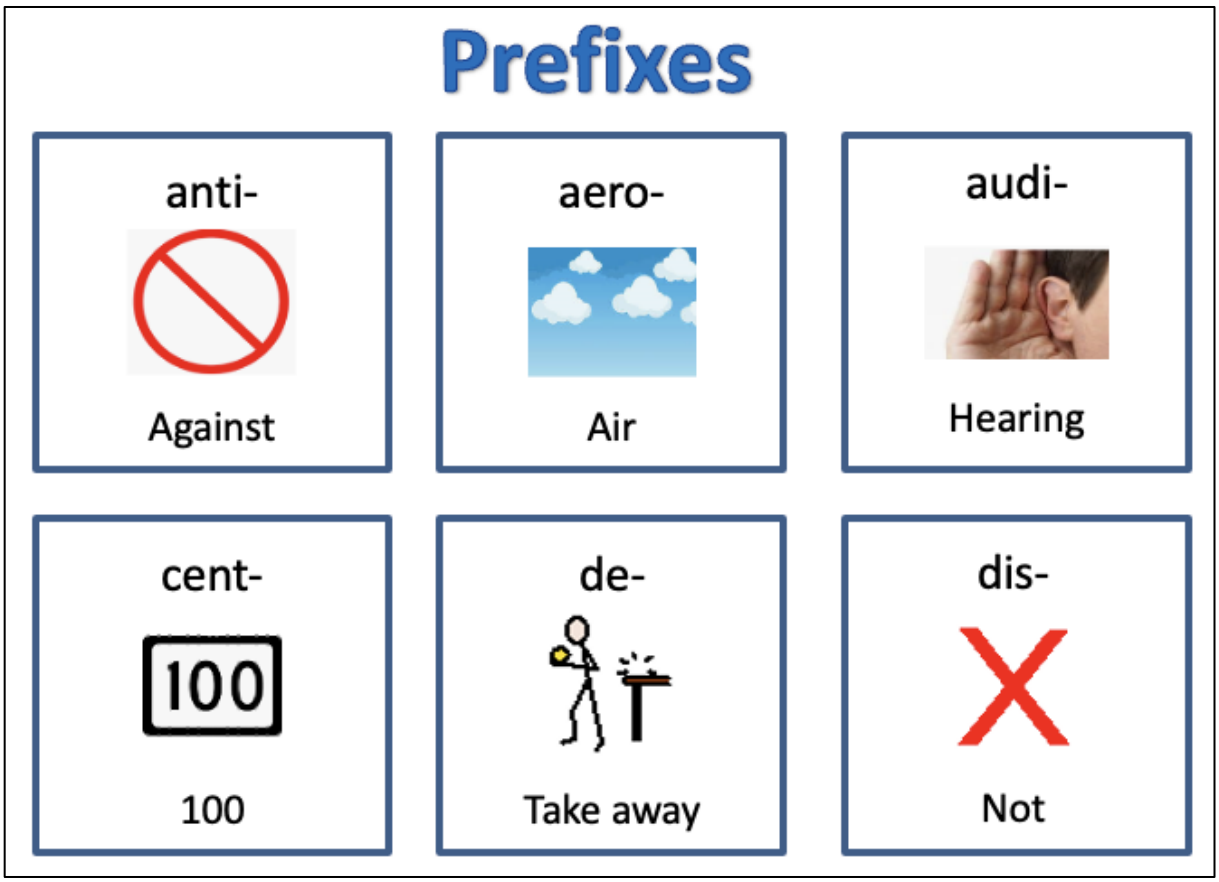
Supplementary Information 2

Prefix, suffix, root poster



Supplementary Information 3

Affix picture cards



Supplementary Information 4

Example morpheme study table

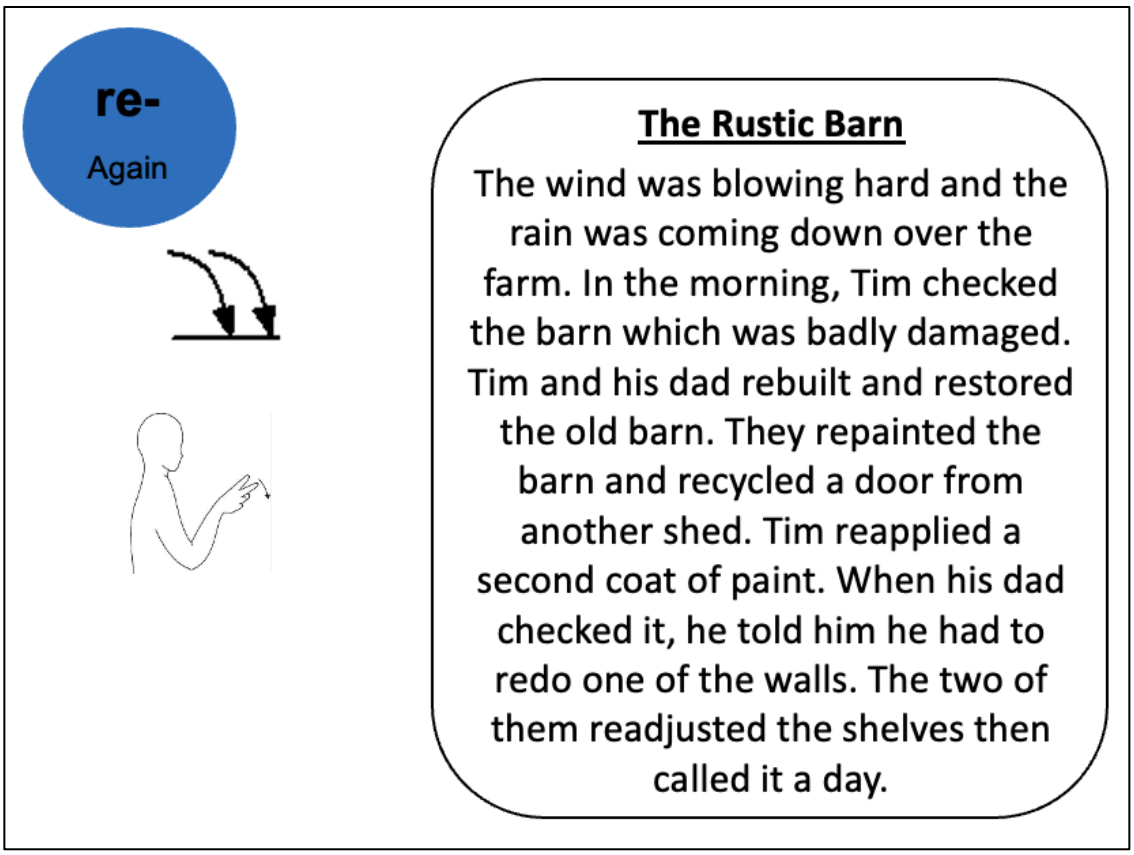
Morpheme study table

Prefix: De-

Derail	Declutter	Devalue	Deflect
Definition	Definition	Definition	Definition
Picture	Picture	Picture	Picture
Sentence	Sentence	Sentence	Sentence

Supplementary Information 5

Example reading comprehension task



Supplementary Information 6

Example reflection sheet for main intervention sessions

1. **Write down the morphemes and their meanings that you learnt today.**

Prefixes	Suffixes

2. **Draw a picture of the morphemes you learnt today.**

Prefixes	Suffixes

3. **Write down 4 words you used today:**

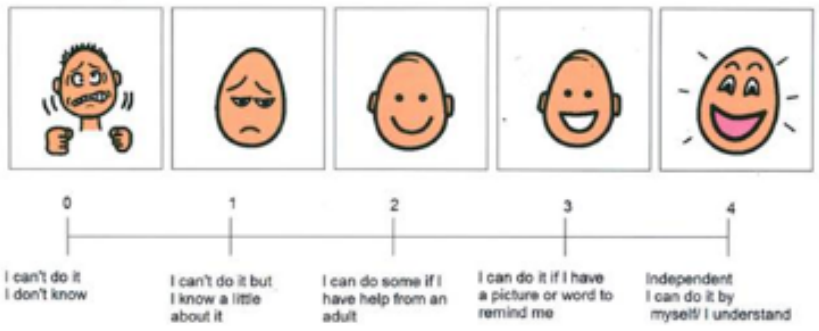
1) _____ 3) _____

2) _____ 4) _____

4. **When will you use the morpheme this week?**

_____

5. **How was today's session?**



Supplementary Information 7

Main intervention session components with example scripting

Component	Explanation and examples
1. Learning intention	SLP shares learning intention for the session. E.g., SLP: *"This term we are learning about parts of words and their meanings. This is because it will help you learn and understand the meanings of new or tricky words in English, Science, Maths and other lessons. Today we are going to learn the morpheme 'audi-'"*
2. Review meaning of *prefix, suffix*, and *root*	SLP and students review meaning of prefix, suffix, and root using the explicit teaching poster (Supplementary Information 1). Step 1: Student retrieves from prior learning. E.g., SLP: *"Can you remember what the words – prefix, suffix and root word mean?"* Step 2: Teach. E.g., SLP: "*Words can be made up of smaller word parts – like in the word 'undoing' – the beginning part of the word is un-, the middle part is do- and the end part is –ing. The beginning part of the word is called a prefix, the middle part of the word is called a root and the end part of the word is called a suffix."* Step 3: Check for understanding and repeat teaching as required. E.g., SLP: *"What does prefix mean?"*
3. Review and retrieve target affixes	SLP and students review all intervention and basic set affixes and their definitions using picture cards (Supplementary Information 2). E.g. SLP: *"This term we are learning the meanings of these prefixes and suffixes. Let's read and say each prefix and suffix and its meaning together."* As SLP presents each affix picture card, the students and SLP say, read and gesture each affix followed by a definition. E.g.,*"Anti- means against. Aero- means air. Audi- means hearing."*
4. Explicitly teach target affix for the session.	Using a scripted student friendly definition, SLP teaches the target affix for the session. The script is combined with a gesture and picture. Using imitation, repetition and retrieval practice through questioning, the students learn the affix and its meaning. E.g., SLP: "*The prefix we are learning today is un-.* [write un- on mini whiteboard]. *Un- means <u>not</u> or <u>reverse</u>* [say with gestures]. *What does un- mean?"* Students: *"not or reverse"* SLP: *"That's right. In 'unhappy' it means not. When you're unhappy, you're not happy. In 'unfriendly' it also means not. If you're unfriendly, you're not friendly. What does un- in unfriendly and unhappy mean?"* Students: *"not"* SLP: *"That's right. Un- can also mean reverse like in 'undo your laces' or 'unzip your coat'. What does un- in undo or unzip mean?"* Students: *"reverse"*
5. Complete affix mat	SLP and students fill in an affix mat for the target affix. The affix mat is a graphic organiser that includes the target affix in the middle of the page and boxes around the page with space for the participant and SLP to write a definition of the affix, write example words containing the affix and write a sentence containing one of the words.

		SLP elicits imitation and repetition of the affix, its definition and examples of words using questioning throughout the task.
6.	Complete morpheme table	SLP and students fill in morpheme table (Supplementary Information 3). Using a gradual release of responsibility, SLP and students identify the prefixes, suffixes and roots in each of the four given words. They then define the meaning of each morpheme, define the words and discuss how each affix contributes to the meaning. Finally, they use the words in sentences and draw pictures to depict their meanings.
7.	Reading passage	SLP and students read a passage aloud that contains multiple examples of the target affix (see Supplementary Information 4). After reading the passage, SLP guides students to identify and highlight any words containing the target affix. The SLP or students write the identified words on a mini whiteboard. SLP and students then break the word into its affixes and discuss how the meaning of each affix contributes to the overall meaning of the word. E.g., *"The word 'repainted' is made up of 3 morphemes – re-, paint- and -ed. -ed means that it happened in the past. Re- means that its happened again. So repainted means that it has been painted again."*
8.	Reflection sheet	To summarise the learning and encourage generalisation of the taught affix outside of the session, the SLP guides the students to complete a written reflection sheet (see Supplementary Information 5) which includes questions on what affix was taught, what it means, what words were used and when they might use the affix outside of the session. If the students have significant literacy difficulties, the SLP completes the sheet with input from the students.

Supplementary Information 8

Example review worksheet (3 pages)

Name_____ Date_____

Morphological Analysis

Recap!

Match the prefixes to their meaning:

re- (redo, reorder, retie)	take away or make smaller
de- (defrost, declutter)	not, don't or the opposite
dis- (displease, dislike)	do it again or go back

Think of some example words with the prefix. Can you explain what they mean?

re-	de-	dis-

Name_____ Date_____

Morphological Analysis

Complete these sentences. Fill in the missing prefix.

- I need to _____heat my dinner because it's gone cold.
- Sarah completely _____agreed with Lisa about which type of cake was the best.
- My car windscreen needs _____frosting so that I can see the road!
- I _____like sardines.
- My brother's room is such a mess. He really needs to _____clutter.
- Your shoelaces keep coming undone. Do you want me to _____tie them for you?
- Jane forgot to bring her lunch to school with her. She is so _____organised!
- It was a very hot day, so we started to feel _____hydrated.

Name_____ Date_____

Morphological Analysis

Add prefixes to these words to make new words. Can you think of some more?

-de dis- re

Root wood	+ Prefix	Meaning
Lock		
frost		
Heat		
Like		
Agree		
Compose		
Comfort		
Write		
Use		
Stress		
Cycle		
Colour		
Think		

Supplementary information 9

S

*CONSORT 2010 checklist of information to include when reporting a randomised trial**

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	2
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	1
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	2-7
	2b	Specific objectives or hypotheses	7-8
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	8
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	8
Participants	4a	Eligibility criteria for participants	9-10
	4b	Settings and locations where the data were collected	9
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	10-15
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	16-18
	6b	Any changes to trial outcomes after the trial commenced, with reasons	10, 11, 15, 16
Sample size	7a	How sample size was determined	9
	7b	When applicable, explanation of any interim analyses and stopping guidelines	n/a
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	10-11
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	10-11
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	10-11
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	10-11
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those	

		assessing outcomes) and how	16
	11b	If relevant, description of the similarity of interventions	11-12
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	19-21
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	19-21
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	Fig 1, 9-10
	13b	For each group, losses and exclusions after randomisation, together with reasons	Fig 1, 9-10
Recruitment	14a	Dates defining the periods of recruitment and follow-up	8
	14b	Why the trial ended or was stopped	8
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Table 1
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	19, 21-23
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	Tables 5-7
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	n/a
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	n/a
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	25
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	24
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	23-25
Other information			
Registration	23	Registration number and name of trial registry	Data and code availability 26
Protocol	24	Where the full trial protocol can be accessed, if available	n/a
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	26

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

CONSERVE-CONSORT Extension: [19th March 2025]					
Item	**Item Title**	**Description**			**Page No.**
I.	Extenuating Circumstances	Describe the circumstances and how they constitute extenuating circumstances.			P8
II.	Important Modifications	a. Describe how the modifications are important modifications.			P8
		b. Describe the impacts and mitigating strategies, including their rationale and implications for the trial.			(see below)
		c. Provide a modification timeline.			P8
III.	Responsible Parties	State who planned, reviewed and approved the modifications.			P8 & 15
IV.	Interim data	If modifications were informed by trial data, describe how the interim data were used, including whether they were examined by study group, and whether the individuals reviewing the data were blinded to the treatment allocation.			n/a
CONSORT Number and Item		For each row, if important modifications occurred check "direct impact" and/or "mitigating strategy" and describe the changes in the trial manuscript or supplement. Check "no change" for items that are unaffected in the extenuating circumstance.			**Page No.**
		No Change	**Impact***	**Mitigating Strategy****	
1	Title and abstract	✓			
2	Introduction	✓			
3	Methods: Trial Design		✓		
4	Methods: Participants	✓			
5	Methods: Interventions			✓	P8, 15, 16
6	Methods: Outcomes		✓		P10
7	Methods: Sample Size	✓			
8-10	Methods: Randomisation	✓			
11	Methods: Blinding	✓			
12	Methods: Statistical methods	✓			
13	Results: Participant flow		✓		P8
14	Results: Recruitment	✓			
15	Results: Baseline data	✓			
16	Results: Numbers analysed	✓			

	Results: Outcomes and estimation	✓			
18	Results: Ancillary analyses	✓			
19	Results: Harms	✓			
20	Discussion: Limitations		✓	✓	P25
21	Discussion: Generalisability	✓			
	Other information: Registration				
24	Other information: Protocol	✓			
25	Other information: Funding	✓			

*Aspects of the trial that are directly affected or changed by the extenuating circumstance and are not under the control of investigators, sponsor or funder.
**Aspects of the trial that are modified by the study investigators, sponsor or funder to respond to the extenuating circumstance or manage the direct impacts on the trial.