

The nature and causes of children's grammatical difficulties: Evidence from an intervention to improve past tense marking in children with Down Syndrome

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Research Highlights:

- After 10 weeks training, children with Down syndrome showed substantial improvements in their use of regular simple past tense verb forms

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- Improvements generalised to untrained verbs and also resulted in overregularisation errors to irregular verbs, indicating that children had acquired generative knowledge underlying past tense marking
- These results demonstrate that children with severe grammatical difficulties can, with appropriate intervention, be taught to master grammatical rules

Keywords: grammatical development, RCT, language intervention, Down syndrome, past tense, teaching assistants

Abstract

Children with language learning difficulties frequently display problems learning grammar. One such group are children with Down syndrome. This study evaluates the effectiveness of an intervention to teach the use of the regular simple past tense to children with Down syndrome. Trained teaching assistants delivered the intervention for 20 minutes per day for 10 weeks. We conducted a Randomised Controlled Trial, with a waiting list control design in which the Intervention group (N=26) received the intervention immediately, while the delayed intervention group (N=26) received the intervention later. Immediately following the intervention, the intervention group showed significantly larger gains in the use of regular simple past tense forms ($d = 1.63$ on a composite measure of simple past tense formation) as well as generalisation to verbs not explicitly taught. In addition, following the intervention children made overregularisation errors by incorrectly using regular simple past tense marking for irregular verbs; such errors support the claim that children had acquired generative knowledge underlying past tense marking. The delayed intervention control group showed identical benefits from the intervention when they received it, and the gains shown by the intervention group were maintained at follow up testing. This study shows that children with Down syndrome, who display severe language difficulties can be taught to use simple past tense marking. The theoretical and applied implications of these findings for understanding the nature, causes and treatments of children's language difficulties are discussed.

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Introduction

The current study focusses on the grammatical difficulties seen in children with Down syndrome. These children experience severe difficulties with grammar which have been likened to those experienced by children with Developmental Language Disorder (Laws & Bishop, 2003), however, to date there is little research on how to remediate their language difficulties. We focus particularly on learning the regular simple past tense form of verbs which can be seen as a paradigm case of what is interesting about child language acquisition (Pinker, 1999; Pinker & Ullman, 2002). We consider two questions. 1. Can children with Down syndrome, given appropriate teaching, master the regular simple past tense forms of verbs? 2. If so, what implications do such findings have for the nature of the language learning difficulties seen in these children and others who have problems in learning grammar?

The typical acquisition of simple past tense forms in English

Typically developing children learning English, generally master past tense marking naturally as a result of language exposure between the ages of 3 to 5 years (Owens, 2001). Interestingly, children typically learn the simple past tense *-ed* forms of regular verbs some time after they have already learned to use a number of high-frequency irregular past tense verb forms (Brown, 1973). Furthermore, in the early stages of language development, children often make overregularisation errors whereby irregular past tense forms, that have been previously used correctly, are replaced by errors in which irregular verbs are treated as regular, such as “goed”, “eated” (Brown, 1973; Slobin, 1971). These overregularisation

errors are striking because children go from using high-frequency irregular past tense verb forms correctly (“he went”) and replace these forms with incorrect overregularisation errors (“he goed”) which they are unlikely to have ever heard in the speech input to which they are exposed. Such errors, therefore, provide powerful evidence for generative processes operating to produce the past tense forms for verbs. It remains highly controversial, however, as to whether this depends on learning a formal “add - ed” rule (Prasada & Pinker, 1993) or, instead depends upon analogical processes operating across stored exemplars in associative memory (Blything, Ambridge & Lieven, 2018; Bybee & Moder, 1983,). In the current paper we will use the term grammatical rules as a convenient shorthand for the knowledge underlying the correct use of the simple past tense form of verbs.

Language difficulties in Down syndrome

Down syndrome is the most common genetic neurodevelopmental disorder affecting approximately one in 800 live births (de Graaf, Buckley & Skotko, 2015). It is associated with moderate to severe general learning difficulties (Roberts, Price & Malkin, 2007) and marked delays in language development (Chapman, 1997; Laws & Bishop, 2003). A pattern of strengths and weaknesses is typical of both the cognitive and language profiles of children with Down syndrome. In the domain of language, concrete vocabulary is a relative strength (e.g., Mervis, 1990), while grammar has consistently been shown to be an area of particular weakness (e.g., Perovic, 2006; Ring & Clahsen, 2005).

Morphosyntax has been a particular area of focus in studies investigating expressive language skills in Down syndrome. Morphosyntactic deficits in language production are

common in adolescents with Down syndrome when compared to younger mental-age matched controls (Chapman, Seung, Schwartz, & Bird, 1998; Laws & Bishop, 2003) or controls matched specifically on expressive language ability (Eadie, Fey, Douglas & Parsons, 2002). A meta-analysis (Næss, Lyster, Hulme & Melby-Lervåg, 2011) reported receptive grammar scores were also much poorer than typically developing controls matched on nonverbal mental age, demonstrating that expressive grammatical difficulties cannot solely be explained by speech production difficulties.

Whilst it is unclear whether grammatical development in young children with Down syndrome follows a different pattern to that in typically developing children (Rutter & Buckley, 1994), a cross-sectional study (Chapman et al, 1998) reported frequent omissions of grammatical morphemes in narrative language, including some of the earliest morphemes acquired by typically developing children. A number of factors have been found to determine the acquisition of bound grammatical morphemes (meaning-bearing units that cannot stand alone as a word e.g. possessive *-s* in *Mummy's*, regular past tense *-ed* in *walked*) in typically developing children (O'Grady, Dobrovolsky & Katamba, 1997): syllabicity, phonetic salience and allomorphic invariance play a role, with morphemes that take the form of an additional syllable and/or are always produced in the same way (e.g. *-ing*) emerging earlier. The low phonetic salience of single sound additions to a word (e.g. /t/ in /wɔkt/ ("walked")) may make the mastery of such forms particularly hard for children with Down syndrome, who commonly also experience hearing difficulties (Laws & Hall, 2014).

The use of bound morphemes by children with Down syndrome has received in-depth analysis. There is a suggestion that the use of bound morphemes signalling grammatical contrasts related to nouns (e.g. regular plural *-s*, possessive *-s*) are relatively spared (Eadie et al, 2002) whilst

those signalling verb tense (e.g. regular simple past tense *-ed*, third person present singular *-s*) are particularly difficult for children with Down syndrome (Eadie et al, 2002; Laws & Bishop, 2003; Ring & Clahsen, 2011). These problems in learning to mark verb tense probably reflect the fact that verbs are more complex than nouns, carrying both semantic and syntactic information and so are generally more difficult to learn for all children (Bassano, 2000; Rice, Buhr, & Nemeth, 1990). There is also some evidence that the use of irregular past tense forms of verbs is less impaired in children with Down syndrome than learning to mark regular past tense forms (walk-ed) (Eadie et al, 2002; Laws & Bishop, 2003), which may reflect the fact that irregular verbs typically occur with high frequency in the language (Brown, 1973).

It appears from this brief review, that children with Down syndrome have particular difficulty with rule-based grammatical structures, such as learning to use the *-ed* morpheme to mark the regular simple past tense in English. This profile is similar to that seen in children with Developmental Language Disorder (previously referred to as Specific Language Impairment; see Laws & Bishop, 2003).

The mechanisms of past tense learning

How are the problems in learning grammar seen in children with Down syndrome or Developmental Language Disorder to be interpreted? The procedural deficit hypothesis of language learning disorders (Ullman, 2004; Ullman & Pierpont, 2005) proposes that problems in acquiring regular simple past tense forms provide evidence for an impairment in a procedural (implicit) learning system that is responsible for learning the grammar of a language. According to this theory, lexical (word specific) knowledge in Developmental Language Disorder may often be less impaired than grammatical skills because it depends on

a relatively intact declarative memory system that may compensate for weaknesses in the procedural memory system (Ullman & Pierpont, 2005). Given that a similar profile of relatively less impaired lexical knowledge than grammatical skills is also observed in children with Down syndrome (Næss et al., 2011), the procedural deficit hypothesis may also be relevant to explaining the language learning weaknesses seen in these children, and others who show particular difficulties with grammatical development.

If children with Down syndrome are unable to learn implicitly the grammatical rules present in language input in the way that typically developing children do, techniques that rely on explicit teaching may be particularly relevant to overcoming such problems. The procedural deficit hypothesis has been argued to show some success in guiding intervention in populations without intellectual disability (Calder, Claessen, Ebbels & Leitão, 2021). In this view, interventions might be able to overcome deficits in procedural learning (abstracting rules implicitly from repeated inputs) by recruiting the declarative (explicit) memory system, as a compensatory resource, to allow rules to be learned explicitly. However, it is unclear from this view how well generalisation would be expected to occur. If a child learned explicitly that the simple past tense form of the verb walk is marked with the *-ed* morpheme, would they be expected to generalize such knowledge to generate the correct past tense of another regular verb (e.g. “dance”) in spontaneous speech? This seems doubtful, since according to this theory children might learn declaratively the correct regular simple past tense forms of certain verbs without necessarily abstracting a general rule that could be used productively with other verbs during language production. In this view then, overregularisation errors are tied to the operation of a procedural memory mechanism, that is responsible for the creation of implicit, unconscious rules that govern spontaneous language use. In contrast the declarative memory system may be responsible for item specific memory for certain word specific

forms (including knowledge about word forms and meanings, and irregular past tense forms of verbs that do not conform to grammatical rules). A critical issue therefore, is whether children can be taught to use regular simple past tense forms effectively, and particularly, whether such training generalises to the use of untrained verbs.

In line with the procedural deficit hypothesis, Calder, et al. (2021) proposed that explicit instruction would be more effective in helping children with Developmental Language Disorder to learn regular past tense verb forms than using implicit techniques, as it harnesses spared declarative memory processes in these children. They found that an explicit intervention improved the use of regular past tense forms in children with Developmental Language Disorder, with very large gains for the intervention group ($d = 3.03$) compared to the control group and these gains generalized to verb forms not directly taught in their intervention. However, they also acknowledged evidence supporting input-based implicit intervention to treat verb morphology in children with Developmental Language Disorder (Eidsvåg, Plante, Oglivie, Privette & Mailend, 2019; Owen Van Horne, Fey & Curran, 2017). They concluded that a combination of explicit intervention procedures with empirically supported input-based procedures could optimize interventions designed to improve the learning of grammatical rules in children with Developmental Language Disorder.

An intervention to teach the regular simple past tense

Children with Down syndrome, like other groups including children with Developmental Language Disorder, typically have severe difficulties learning the grammar of their native language. However, there is currently limited evidence that these children can be taught to use the regular simple past tense form of verbs in English successfully. No reports of randomised controlled trials

targeting grammar in large samples (above 20 participants) of individuals with Down syndrome have been reported.

Two studies (4-6 participants) targeting morphosyntax (Camarata, Yoder & Camarata, 2006; Finestack, O'Brien, Hyppa-Martin & Lyrek, 2017) reported gains in mean length of utterance (MLU). However, small sample sizes, an absence of measures of specific grammatical morpheme use and the short duration of the interventions (5-18 sessions) severely limit the conclusions that can be drawn from these studies.

A study with a slightly larger sample evaluated the effectiveness of a morphosyntactic intervention with Spanish-speaking participants with Down syndrome (Sepúlveda, López-Villaseñor & Heinze, 2013). Although limited detail is provided, more progress was reported for 10 children in an experimental group (mean age 10 years 5 months, SD 23 months) than the control group (mean age 10 years 9 months, SD 29 months). All participants received two half-hour sessions twice a week, with a total of 30 sessions over 3.5 months. The control group continued to receive "habitual" speech and language therapy (no detail provided), while the experimental group followed a new intervention programme delivered by the same therapists, who had been trained to deliver it. The intervention sessions either targeted a specific morpheme (with a maximum of 2 sessions given to each morpheme) or sentence structures (5 sessions) or dialogues (5 sessions). At the end of the 3.5 month intervention, the authors reported that children in the experimental group improved more than children in the control group on an assessment of expressive morphology, semantics and syntax although no effect sizes are reported. Crucially, no details were given for the control group therapy and very few details of the test that was used before and after the intervention were provided. Whether any gains generalised to novel items is not clear from this study.

Several other small scale studies report successful use of structured programmes for teaching syntax (e.g. colour coding and/or shape coding parts of the language) with children with intellectual difficulties that include children with Down syndrome (Bibi, Mumtaz & Saqulain, 2019; Hettiarachchi, 2015; Tobin & Ebbels, 2018). An intervention using a shape coding system (Tobin & Ebbels, 2018) found significant gains for tense and plural agreement marking in copulas and auxiliaries ($d=0.92$) for 8/11 participants (6 of whom had Down syndrome).

Although limited, this evidence suggests that an intervention specifically focussing on a grammatical morpheme could potentially be successful with children with Down syndrome. As tense related morphemes are a particular area of difficulty for people with Down syndrome (Eadie et al, 2002; Laws & Bishop, 2003; Ring & Clahsen, 2011), an intervention targeting these forms seems particularly valuable and was chosen as the focus of the current study. If the intervention is effective for targeted verbs, it is important to know if participants can generalize such knowledge of the regular simple past tense to non-targeted verbs and whether this results in them applying the rule to irregular verbs, as seen in typical language development. The intervention reported here is multi-faceted and includes aspects of both implicit and explicit instruction.

The aim of the current study was to investigate the following two questions:

1. How effective is an intervention that teaches the use of the regular simple past tense forms, using implicit and explicit techniques, for children with Down syndrome?
2. If such an intervention can be shown to be successful, will learning generalize, and, in particular, will children demonstrate overregularisation errors after the intervention? If overregularisation errors do occur they provide strong

evidence for the mastery of a generative system (rule) underlying regular simple past tense formation.

Method

A randomised control trial (RCT) was conducted with 52 children with Down syndrome to evaluate the effectiveness of a programme designed to teach the use of the regular simple past tense forms of verbs (Past Tense Intervention – ‘PaTI’) to children with Down syndrome. We used a waiting list control design in which half the sample (N=26) received the intervention immediately, while the other half (N=26) received the intervention later. Participants were recruited from mainstream primary schools and were randomly allocated to two groups: the intervention group received the PaTI intervention in the first 10 weeks while the delayed intervention group, received “business as usual” for the first 10 weeks, followed by 10 weeks of the PaTI intervention. Children were recruited in two cohorts in consecutive school years. Trained teaching assistants delivered the language intervention to the children on an individual basis in daily 20-minute sessions in the children’s schools. All children were assessed at three time points: pre-intervention (t1), immediately after the intervention group had received the 10 week intervention (t2) and approximately 14 weeks later, after the delayed intervention group had received the intervention (t3) (during which time the intervention group returned to ‘business as usual’). Please note that business as usual in the context of this study involved many children receiving some speech and language therapy (see Participants section below for further details). In accordance with the CONSORT guidelines (Schultz, Altman, & Moher, 2010), details of the allocation of participants and intervention delivery is presented in Figure 1. The study received ethical approval from the UCL Ethics Committee.

Participants

The study was advertised to all mainstream schools across Hampshire, UK using contact data from the local authority website. In addition, local groups supporting children with Down syndrome were contacted and asked to share the recruitment information with families. Recruitment occurred in two consecutive years during September-November 2016 and September-November 2017. Once recruited, children were then assessed between November-December (2016=32 participants, 2017=20 participants).

Fifty-five potential participants with Down syndrome aged 7-11 years were identified at the start of the study as meeting the following inclusion criteria; a) attending Year 3-Year 6 in mainstream schools, b) speaking English as their first language (two children had an additional language spoken at home, Spanish and Polish, but English was their first language), c) combining two or more words in utterances, as reported by parents and/or school. All 55 participants completed two tests from the intervention battery to confirm that they matched a further two inclusion criteria; d) the ability to produce the sounds to mark the regular simple past tense (articulation did not have to be accurate), measured using the Phonological Probe from the Test of Early Grammatical Impairment (TEGI) (Rice & Wexler, 2001), e) failing to use regular simple past tense accurately, measured using the Renfrew Action Picture Test (Renfrew, 1997) and the Past Tense Probe from the TEGI. The age range of 7-11 years was targeted based on previous research showing that children with Down syndrome of this age would be expected to meet our recruitment criteria for levels of language (Chapman et al, 1998) and speech (Burgoyne, Buckley & Baxter, 2021). Three of the 55 children were excluded from the intervention because they were already marking the regular simple

past tense accurately in over 80% of responses on the TEGI Past Tense Probe and responded with at least one past and present tense form on the Renfrew Action Picture Test.

The 52 participants selected came from 47 schools. All the children had support from a teaching assistant for a large part of the school day. Participants were allocated to the Intervention or Delayed Intervention group, using simple randomisation in Stata 17.0 (StataCorp, 2021) and all participants remained in the groups they were allocated to. A total of 38 families (73.1%) provided background information regarding their child. All except two children were reported to have Down syndrome in the form of Trisomy 21, the remaining two parents reported “unknown”. Current speech and language therapy targets were also requested from parents: 7.9% reported their child had been discharged, while another 60.5% indicated that the most common targets for current therapy were syntax (82.6%), vocabulary (69.6%) and speech (60.8%) (children could have targets in more than one area). Only 2 participants had targets relating to grammatical morphology and only one was working on tense marking. Consent was gained from parents for their child to participate and signed agreement was obtained from the head teacher at the schools as well as the teaching assistants who delivered the intervention.

Assessments

All assessments were conducted individually by the first author in school. Teaching assistants and parents were able to attend assessment sessions with their child. Assessments were conducted in a fixed order and typically took place over 1-2 half days (2-4 hours plus breaks) although more visits were offered if necessary. Assessments were video-recorded to ensure accurate transcription and so that inter-rater reliability checks could be conducted; this was deemed to be particularly important for the Renfrew Action Picture Test (RAPT) and the Narrative Retell measures which

require relatively complex judgements when scoring. Inter-rater reliabilities were excellent for all of these measures: RAPT Grammar (ICC = .999) RAPT Information (ICC = .942), Narrative Retell (ICC = .998).

Baseline assessments (administered only at pre-intervention (t1))

Non-verbal mental age – assessed using the Ravens Coloured Progressive Matrices (Raven, 2008). Maximum raw score 36 (Cronbach's alpha = 0.80).

Vocabulary – assessed using the Receptive One Word Vocabulary Test (ROWVT) and the Expressive One Word Vocabulary Test (EOWVT) (Brownell, 2000). Maximum raw score on both 170 (Cronbach's alpha = 0.96).

Receptive grammar – measured using the Test of Reception of Grammar II (TROG-II) (Bishop, 2003). Maximum raw score 80 (Cronbach's alpha = 0.87).

Expressive grammar – measured using the Recalling Sentences subtest of the Clinical Evaluation of Language Fundamentals (CELF-4 UK) (Semel, Wiig, Secord & Hannen 2006). The administration guidelines were amended slightly for this assessment alone. Due to the expressive grammar difficulties associated with Down syndrome, all participants started at item 1 regardless of age (guidance states the 9-11 year olds in the present study should have started at item 6). Transcription and scoring was checked via the recording, any unintelligible units were excluded. Maximum raw score 96 (alternate forms reliability $r = 0.93$).

Speech production – measured using the Phonological Probe from the Test of Early Grammatical Impairment (TEGI) (Rice & Wexler, 2001). The child's ability to produce the speech

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sounds required to mark past tense (/t/ as in jumped=/dʒʌmpt/ and /d/ as in crawled=/krɔ:ld/) was assessed. This probe asks the child to name 10 pictures, five with final sound /t/ and five with final /d/ (e.g. foot=/fʊt/, bed=/bed/). Maximum raw score 20 (Cronbach's alpha = 0.82).

Word reading – measured using the Early Word Reading subtest from the York Assessment of Reading for Comprehension (YARC) (Snowling et al., 2009). Maximum raw score 30 (Cronbach's alpha = 0.98).

Letter sound knowledge – measured using the Letter Sound Knowledge (core version) subtest from the YARC. Maximum raw score 17 (Cronbach's alpha = 0.95).

Intervention test battery (administered pre-intervention (t1), post-intervention (t2) and 3 month follow up (t3))

Expressive grammar and information – measured using the Renfrew Action Picture Test (RAPT) (Renfrew, 1997). Ten pictures are presented to elicit a sample of spoken language with separate scores being generated to reflect the information conveyed and the grammatical structures used. Maximum score Information 40 (Cronbach's alpha = 0.86), Grammar 37 (Cronbach's alpha = 0.74).

Irregular and regular past tense – measured using the Past Tense Probe from the Test of Early Grammatical Impairment (TEGI). Eighteen pairs of pictures are presented on a computer. The first shows a person performing an action and the second a person having completed the action. The child is told what the person is doing in the first picture before the assessor points to the second picture and states that the person has finished. The child is then asked to say what the person did. Maximum score 18 (Cronbach's alpha = 0.82).

Third person singular – measured using the Third Person Singular Probe from the TEGI. Ten pictures are shown one by one on a computer screen. The child is told the role of the person in the picture (e.g. a teacher) and the child is then asked to say what the person does. Maximum score 10 (Cronbach's alpha = 0.92).

In addition to the standardised measures, bespoke measures were used to assess the child's use of the regular simple past tense.

Taught Regular Simple Past Tense Probe (TRSPTP). Tests were created to measure the child's use of the regular simple past tense for the 40 verbs explicitly taught in the intervention. These verbs were predominantly selected from the Vocabulary Checklists 1, 2 and 3 (Down Syndrome Education International, 2009) which lists words commonly used in early vocabulary acquisition. The selected verbs included examples of the three different phonological forms used to mark the regular simple past tense in English: 1) the addition of /t/ after voiceless sounds (e.g. jumped=/dʒʌmpt/) (N=14); 2) the addition of /d/ after voiced sounds (e.g. crawled=/krɔ:lɪd/) (N=14); 3) the addition of /ɪd/ after some verbs ending in /t/ or /d/ (e.g. planted=/plɑ:ntɪd/) (N=6). The addition of the syllable /ɪd/ is less common in English and this is reflected in the fact that fewer /ɪd/ forms were used in the intervention. The test was modelled on the TEGI and involved showing the children 40 pairs of pictures, with the first showing a person performing an action and the second a person having completed the action (e.g. a girl crawling under a chair then the same girl standing beside the chair). The assessor pointed to the first picture and told the child what the person was doing before pointing to the second picture and asking the child to say what the person had done (e.g. "here the girl is crawling (point to first picture), here she has finished (point to second picture), tell me what she did"). Maximum score 40.

Untaught Regular Simple Past Tense Probe (URSPTP) – in addition to the 40 taught verbs, 20 untaught verbs were presented in the same way. These verbs were matched for age of expected acquisition based on the Vocabulary Checklists (Down Syndrome Education International, 2009) and the type of phonological form required (voiceless /t/ (N=9), voiced /d/ (N=8), additional syllable /ɪd/ (N=3)). Maximum score 20.

Regular Simple Past Tense Sentence Repetition – this test required the child to repeat 10 simple sentences where the transitive or intransitive verb is marked for past tense (e.g. “the girl crawled”). Maximum score 30.

Narrative Retell – this test assessed the child’s use of the regular simple past tense when retelling a story and is a modified version of an assessment used previously with pre-school children (Fricke, Bowyer-Crane, Haley, Hulme & Snowling, 2013). In our modified version children were shown four pictures while the assessor read a script containing nine verbs marked by the regular simple past tense. As the script was read, the assessor pointed to the relevant parts of the story as depicted in the pictures. The child was then asked to retell the story while the pictures remained in view. A pilot study showed that 4 children with Down syndrome coped with this task well. The child’s retell was scored for: Total number of words used (TNW); Number of Different words used (NDW); Mean length of utterance (MLU); and the number of regular simple past tense verbs used. Maximum past tense score was 9.

The Intervention Programme

The Past Tense Intervention (PaTI) programme was developed by the first author and specifically targets regular simple past tense marking in English contrasting it with the present

continuous tense. The programme uses a combination of the following strategies that have been used in previous successful interventions: modelling of expressive language targets in context (Buckley, 1993; Sepúlveda et al, 2013; Yoder, Woynaroski, Fey & Warren, 2014); use of recasts (Camarata et al, 2006); multiple repetitions of the target structure (Burgoyne, Duff, Clarke, Buckley, Snowling & Hulme, 2012; Sepúlveda et al, 2013); use of text to support learning, comprehension and memory for spoken language (Buckley, 1993; Buckley, 1995; Mengoni, Nash & Hulme, 2014) and explicit explanation of grammatical rules (Bibi, Mumtaz & Saqulain, 2019; Hettiarachchi, 2015; Tobin & Ebbels, 2018).

PaTI is a 10-week programme delivered in daily 20-minute sessions with each week focussed on four verbs (40 verbs in total). A number of studies have found significant gains on vocabulary (Burgoyne et al, 2012), morphology, semantics and syntax (Sepúlveda et al, 2013) and articulation (van Bysterveldt, Gillon & Foster-Cohen, 2009) in interventions of this frequency and duration.

Trained teaching assistants delivered the scripted PaTI programme. Whilst the teaching assistants were not blind to whether they were in the intervention group (delivery in the first 10 weeks), they did not receive the training until two weeks before they started delivering the intervention. This was to ensure that the time between receiving training and the start of delivery was controlled for both groups and that the delayed intervention group could not start the intervention early, contaminating any outcomes. Training to deliver the intervention included directions to the teaching assistants on how to tailor the activities to meet the needs of individual children. The intervention followed the same structure each week; an overview of the structure of the daily sessions can be found in Appendix 1.

Teaching assistants attended a day of training in the two weeks prior to starting the intervention. The training covered the rationale for the intervention techniques, guidance on general administration regarding the structure and detail of the intervention as well as providing the manual and resource pack for the intervention which the trainer worked through with the participants. The first author visited the participants fortnightly during the intervention, observed the intervention session for that day, and provided feedback, support and encouragement to the TAs delivering the programme. The PaTI programme was scripted and these observations confirmed that TAs were typically following the session plans closely. The TAs delivering the programme kept records of the number of sessions attended; most children received the majority of sessions they were expected to receive (maximum possible 50 sessions): intervention group mean 41.30 (SD 8.22), delayed intervention group mean 42.08 (SD 9.19).

Analyses

Analyses were conducted in Stata 17.0 (StataCorp, 2021). The aim of our RCT was to test whether, with a targeted intervention, children with Down syndrome could be taught to mark the regular simple past tense form of verbs. We collected multiple measures of this key outcome at both pretest and posttest. In order to simplify analyses, and increase power, while making minimal assumptions we created a composite measure of regular simple past tense use by averaging z-scores of these measures. To assess whether the intervention was associated with improvements in simple past tense marking we used analysis of covariance (ANCOVA) models with group (Intervention vs Delayed Intervention) dummy coded and the relevant pretest score as a covariate. These ANCOVA models assume that the slope relating pretest to posttest scores is equivalent for both groups; this assumption was supported for all the models reported here. The size of intervention effects are

calculated as the difference in progress between groups, divided by the pooled pretest SD on the same measure at t1 (Morris, 2007).

Results

Descriptive statistics for each group on all outcome measures at t1, t2 and t3 (pre-intervention, after the intervention group had received the intervention and finally after the delayed intervention group had received the intervention) are shown in Table 1.

As expected given random allocation the two groups have generally similar scores on all tests at baseline. Overall, participants performed better on tests of vocabulary (Receptive One-Word Vocabulary Test mean standard score 73.85 (95% CI 72.03, 75.66), Expressive One-Word Vocabulary Test mean standard score 71.32 (95% CI 67.95, 73.44)) than they did on a test of receptive grammar (TROG-II) mean standard score 55.48 (95% CI 54.94, 56.02). As is evident from the confidence intervals for these measures, performance on TROG-II was significantly lower than on the two tests of vocabulary, which did not differ significantly from each other ($t = 1.92$; $d.f. = 102$; $p = 0.06$). This language profile, with more severe deficits on tests of grammar, than on measures of vocabulary knowledge is typical of this population (Næss et al, 2011; Miller, 1988; Fowler, 1990; Fowler, Gelman & Gleitman, 1994). On the tests of expressive grammar (TEGI and CELF-4), participants were frequently failing to score (percent of participants scoring at floor at t1: TEGI regular past tense 63.46%, TEGI irregular past tense 71.15%, TEGI third person singular 71.15%, CELF-4 sentence repetition 26.92%).

Intervention effects

We used a number of different measures to assess the use of regular simple past tense forms of verbs at all time points: TEGI Regular Past Tense Probe, bespoke Taught Regular Simple Past Tense Probe (TRSPTP), bespoke Untaught Regular Simple Past Tense Probe (URSPTP) and the use of past tense forms in the bespoke Narrative Retell task. These four measures correlated uniformly and highly at t2 and t3 (r_s .76-.97 at t2; r_s .79-.96 at t3) and moderately to strongly at t1 (r_s .49-.86). To determine whether the intervention improved participant's ability to use past tense, a composite score was created by averaging z-scores of these four measures.

The critical comparisons to evaluate the effect of the intervention are the differences between groups at t2 on key measures (after the intervention group has received the intervention but before the delayed intervention group has received it). Figure 2 shows the differences between the groups' marginal means, with 95% confidence intervals from the ANCOVA models. Positive values indicate greater gains in the intervention compared to the control group. The first four measures on the graph (Composite Regular Simple Past Tense, Renfrew Action Picture Test – Grammar, TEGI overregularisation errors, and Regular Simple Past Tense Sentence Repetition) are all expected to show gains after the intervention, and these gains are all significant after applying a conservative Bonferroni correction ($p < .005$). The remaining six measures shown on the graph were not targeted by our intervention, and so, as expected, did not show appreciable gains. It should be noted that the effect sizes reported here need to be interpreted with caution since participants obtained very low scores on many measures at t1, often scoring zero, which is typical of this population (see Table 1). These floor effects at t1 will serve to inflate some of the estimated effect sizes.

The intervention group made significantly greater gains than the delayed intervention group on the regular simple past tense composite score and on the RAPT Grammar measure. As anticipated, the intervention did not transfer to the other measures of expressive grammar (irregular past tense or third person singular) or measures of the amount of information and/or detail used in expressive language (information on the RAPT, total number of words used or number of different words used in the Narrative Retell). However, an important finding, is that there were significant increases in the number of overregularisation errors on the TEGI; indicating that children were applying the regular simple past tense rule, targeted in the intervention, to irregular verbs (i.e. dranked /drɪŋkt/, eated /i:tɪd). This finding is important since it demonstrates that children have abstracted the rule for regular simple past tense formation and are applying it generatively in their language use.

The results presented in Table 1 and Figure 2 show that at t2 the children in the intervention group had made gains (compared to the delayed intervention group who had not yet received the intervention) in their use of the regular simple past tense as assessed by a range of measures with large effect sizes. For example, gains on the regular simple past tense use on the TEGI at time 2 were associated with a very large effect size ($d=3.12$) as were gains on the bespoke Narrative Retell task ($d=1.92$) which was constructed to elicit a story retell as a measure of more spontaneous language use.

Another critical finding is that the intervention group demonstrated the ability to generalise the taught regular simple past tense rule to verbs not taught in the intervention (Bespoke URSPTP $d=3.32$). Some participants overgeneralised the addition of /t/, /d/ or /ɪd/ to irregular verbs (e.g.

drinked /driŋkt/, eated /i:tɪd/) (TEGI $d=5.45$). This finding supports the claim that children were extracting and applying the grammatical rule for past tense formation that they had been taught.

Another issue of interest, is the extent to which there are individual differences between children in the size of gains made in response to our intervention. Figure 3 plots pretest versus posttest scores for both groups, using a raw composite past tense score (a sum of TEGI Regular Past Tense Probe, bespoke Taught Regular Simple Past Tense Probe (TRSPTP), bespoke Untaught Regular Simple Past Tense Probe (URSPTP) and the use of past tense in the bespoke Narrative Retell). The regression functions for the two groups are parallel showing that children with the lowest pretest scores make roughly equivalent gains to children with better pretest scores. However, it is clear from the graph that the intervention was not effective for a small group of children (5/26) with severe grammatical difficulties. It should also be noted however, that for some other children with equally severe grammatical difficulties at pretest, the intervention was associated with large improvements in their scores at posttest.

The data in Table 1 shows that the delayed intervention group made similar gains to the intervention group at t3, once they too had received the intervention. Figure 4 shows a Violin plot of the raw composite regular simple past tense scores (using the same measure as in Figure 3) at t1, t2 and t3 for the intervention and delayed-intervention groups. This plot shows the floor effect on these measures at t1 mentioned above, but also shows clearly that the intervention group make improvements at t2 (immediately after they had received the intervention) compared to the control group. At t3 the delayed intervention group make comparable gains in their past tense scores. The plot also shows that the gains made by the intervention group were maintained at t3, some 12-14 weeks after the Intervention had been completed.

Discussion

This study evaluated the effectiveness of an intervention targeting the use of the regular simple past tense in children with Down syndrome. The intervention included both implicit and explicit teaching. The intervention was effective in improving children's use of regular simple past tense forms of verbs and these effects generalized to untaught verbs.

Intervention Effects

This study is one of the largest RCTs conducted to evaluate a language intervention for children with Down syndrome and shows convincingly that the PaTI programme produced improvements in children's ability to use regular simple past tense forms in their spoken language output, with large effect sizes. The pattern of data in Figure 4 is revealing. Before the intervention many children were at floor on our measures of regular simple past tense use. After the intervention the majority of children made large gains in their use of regular simple past tense forms and these gains were maintained some 12-14 weeks post intervention.

It is also important to stress the form of learning observed. The effects of training were not restricted to verbs targeted in the intervention, since children showed generalisation to the regular simple past tense form for untaught verbs. Strikingly, after the intervention, children also showed an increase in overregularisation errors on irregular past tense verbs (e.g. /kætʃt/ ("caught") and /i:tɪd/ ("eated")). These findings provide strong support for the idea that children had acquired generative knowledge that they could use productively in marking the past tense forms of verbs.

The Procedural Deficit Hypothesis

We may relate the pattern of findings from our intervention to the idea of separate declarative and procedural memory systems as postulated in the procedural deficit hypothesis of language learning disorders (Ullman, 2004; Ullman & Pierpont, 2005). According to Ullman & Pierpont (2005), the language learning difficulties seen in children with Developmental Language Disorder reflect a relatively weak procedural memory system coupled with a relatively intact declarative memory system (Calder et al., 2021; Ullman & Pierpont, 2005). In this view learning the rules underlying the grammar of a language depends on a procedural memory system (implicit or unconscious learning) whereas learning lexical (word level) knowledge depends on a separate declarative memory system (conscious or explicit learning). This contrast between a weak procedural memory system and a relatively intact declarative memory system has been claimed to provide an explanation for why children with Developmental Language Disorder have particularly severe problems learning grammar (dependent on procedural learning) compared to less severely impaired lexical (word specific) knowledge (dependent on declarative memory). Given claims that the language profile in children with Down syndrome is similar to that seen in children with Developmental Language Disorder (Laws & Bishop, 2003) the procedural deficit hypothesis might also be applied to explain why these children also have such severe difficulties learning grammar.

The PaTI programme evaluated here (like the intervention by Calder et al., 2021 for children with Developmental Language Disorder) successfully taught the use of regular past tense forms to children with Down syndrome. Both interventions involved explicit instruction in the rule underlying past tense formation. We believe this explicit instruction is a critical component of the PaTI programme. However, the PaTI programme also involved activities that might support implicit learning such as modelling language targets in context (Yoder et al, 2014) the use of recasts (Camarata et al, 2006) and multiple repetitions of the target structure (Burgoyne et al., 2012). It

remains for future research to clarify the extent to which different components of the PaTI programme are responsible for the learning outcomes observed.

In relating the procedural deficit hypothesis to our findings it is important to draw a distinction between whether *learning* occurs “implicitly” and how *knowledge*, once learned, is used during language production. We believe that explicit instruction in a grammatical rule was one important component of the PaTI programme evaluated here (and the intervention of Calder et al., 2021). However, it seems clear that children in the current study were accessing the knowledge they had been taught about how to mark the regular simple past tense forms of verbs quite automatically. In short, this suggests that declarative (explicit) learning may give rise to rule-like knowledge that is retrieved without explicit or conscious awareness. If this is true it casts further doubt on the usefulness of the procedural learning account which postulates that both (1) the *learning* processes underlying the abstraction of grammatical rules and (2) the resulting knowledge that supports language production, depend on implicit (unconscious) processes (see West, Melby-Lervåg & Hulme, 2021).

Finally, we should emphasise that the children with Down syndrome who participated in this study had difficulties with both regular and irregular past tense forms (as do many children with Developmental Language Disorder). This does not align well with the idea of an intact declarative memory system (responsible for learning irregular past tense forms) and an impaired procedural memory system (responsible for learning rule governed regular past tense forms). However, we should also emphasize, that in contradiction of the Procedural Deficit Hypothesis, there is also ample evidence from many other studies that children with Down syndrome have problems with tasks

involving verbal declarative memory (e.g., Mackenzie & Hulme, 1987; Næss et al., 2011) as well as with implicit tasks (such as learning grammatical rules).

Conclusion and Implications

Children with Down syndrome, like children with Developmental Language Disorder, and some other groups of children, have severe language learning difficulties which may be particularly marked in relation to grammar. The RCT we reported here shows that a 10-week intervention, targeting the ability to mark the regular simple past tense form of verbs, is highly effective. Furthermore children develop a generative skill from the intervention not simply item-specific knowledge. These findings have a number of important applied and theoretical implications.

From an applied perspective our study demonstrates that children with Down syndrome can benefit from a highly targeted intervention focussing on one aspect of grammar. We should emphasise that our results strongly suggest that our participants did not come to understand the linguistic concept of tense. For example, scores on the TEGI did not show improvements in their use of the present tense marker, i.e. the third person singular form *-s* (“Mary walks”). In short, we believe our intervention provides evidence that children with Down syndrome can learn a specific aspect of the grammatical system in English when it is directly taught; other interventions would need to be developed to teach these children other aspects of grammar.

Our intervention is educationally realistic, because it was delivered by teaching assistants who work with the children on a regular basis in school. Teaching assistants were trained by the first author who visited and reviewed an intervention session every two weeks over a 10-week period. This frequency of input is in line with blocks of therapy frequently offered to children in UK schools.

We believe that other targeted language programmes of a similar nature could be developed to improve other aspects of these children's language skills (especially those that are known to be related to difficulties with tense, e.g. the case of pronouns, Reed, 2018). In addition, many other children, including children with Developmental Language Disorder, have difficulties with marking the past tense of verbs and an important issue for future research is to examine whether the PaTI programme described here could be used successfully with such children. As we noted earlier it is clear that a minority of children (5/26) in the current study who started out with severe difficulties marking the regular past tense form of verbs did not benefit from our intervention. However, it would not have been possible to identify these children based on their pretest scores, since other children with similarly low scores at pretest did respond very well to the intervention.

From a theoretical perspective, we believe language interventions potentially provide rich methods for informing theories about the nature and causes of children's language learning difficulties. At a descriptive level, the problems that children with Down syndrome (and Developmental Language Disorder) have in learning the grammatical structures of their language, are well described as reflecting a problem in learning grammatical rules. However, as noted in the Introduction, it remains highly controversial, as to whether such learning depends on the encoding of rules (Prasada & Pinker, 1993) or, instead depends upon analogical processes operating across stored exemplars in associative memory (Bybee & Moder, 1983, Blything, Ambridge & Lieven, 2018). However such generative knowledge is acquired and stored in memory, it is striking, that within a 10-week period the majority of children in this study had made large gains in marking the regular simple past tense of verbs,

and the patterns of errors they made (overregularisation of irregular past tense verbs) provide evidence that they had acquired a generative system.

Limitations

This study evaluated an intervention designed to teach children with Down syndrome regular simple past tense marking for English verbs. Two limitations are that the intervention was relatively brief (10 weeks) and narrow in focus. It would be useful for future studies to explore interventions of a similar form that are both longer in duration and more broadly focused. A further limitation was that the assessor was not blind to the intervention group, although all assessments were recorded and those most likely to yield discrepancies due to their nature, met high levels of inter-rater reliability. However, assessors in future studies should ideally be blinded to group membership. In addition, it would be good if future studies included longer term follow-up measures to assess the durability of the intervention effects observed. It is also important for future studies to explore whether interventions of the form used here can be applied to other populations, such as children with Developmental Language Disorder, who experience similar difficulties in mastering grammar. Notwithstanding, these limitations, it is important to emphasise that the current findings come from a randomized controlled trial and provide evidence that children with Down syndrome, who have severe language learning difficulties (particularly with grammar), can learn one aspect of grammar after just 10-weeks of intervention.

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List of tables and figures

Table 1. Mean raw scores (standard deviation) on all measures at all time points in the study, t1 prior to intervention, t2 post intervention and t3 follow up. The effect size at each time point is calculated as the difference between groups divided by the pooled standard deviation at that time point (Cohen's d), a positive value of d indicates an advantage for the Intervention group compared to the Delayed Intervention group. 95% confidence intervals are given for each value of d ; where the confidence interval does not include zero the difference is significant (indicated by *).

Figure 1. CONSORT diagram showing participant allocation and progress through the randomised control trial.

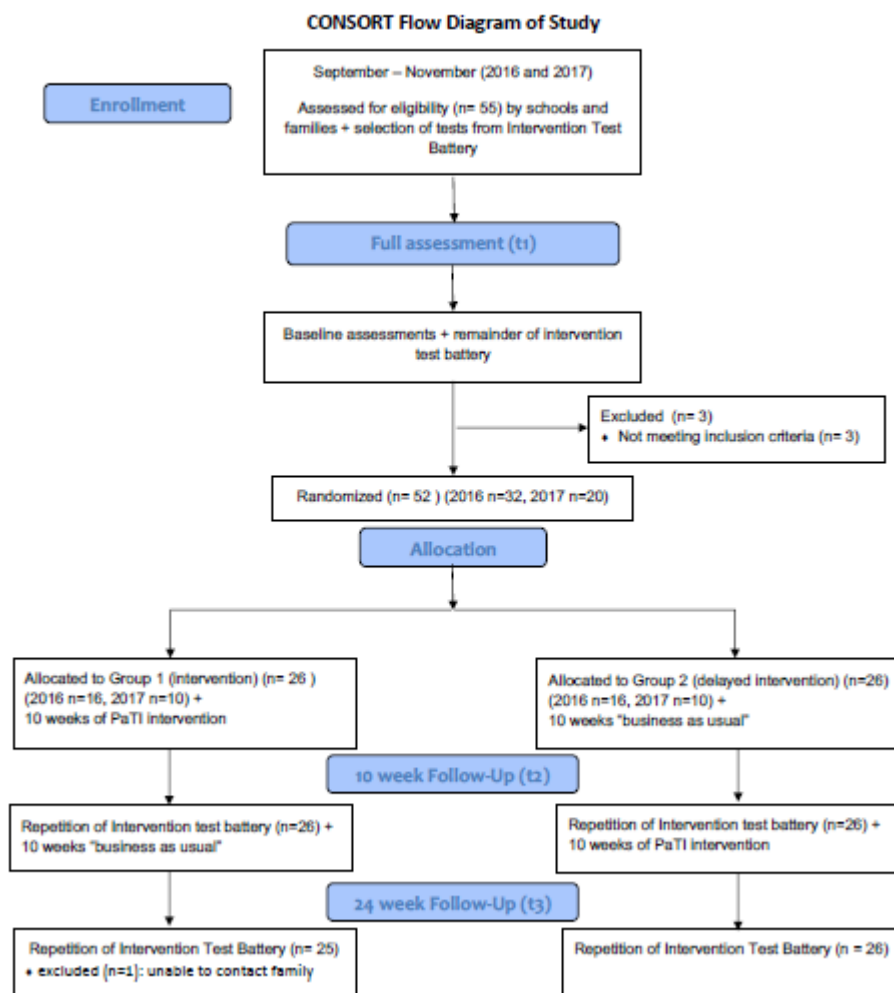


Figure 2. Differences between the marginal means for the intervention and delayed intervention groups at t2 (controlling for the same measure at t1) on intervention outcome measures with 95% confidence intervals, effect sizes (d , difference in raw score gains divided by pooled SD at t1) and p -values.

RSPT=Regular simple past tense; RAPT=Renfrew Action Picture Test; TEGI=Test of Early Grammatical Impairment; MLU=Mean Length of Utterance.

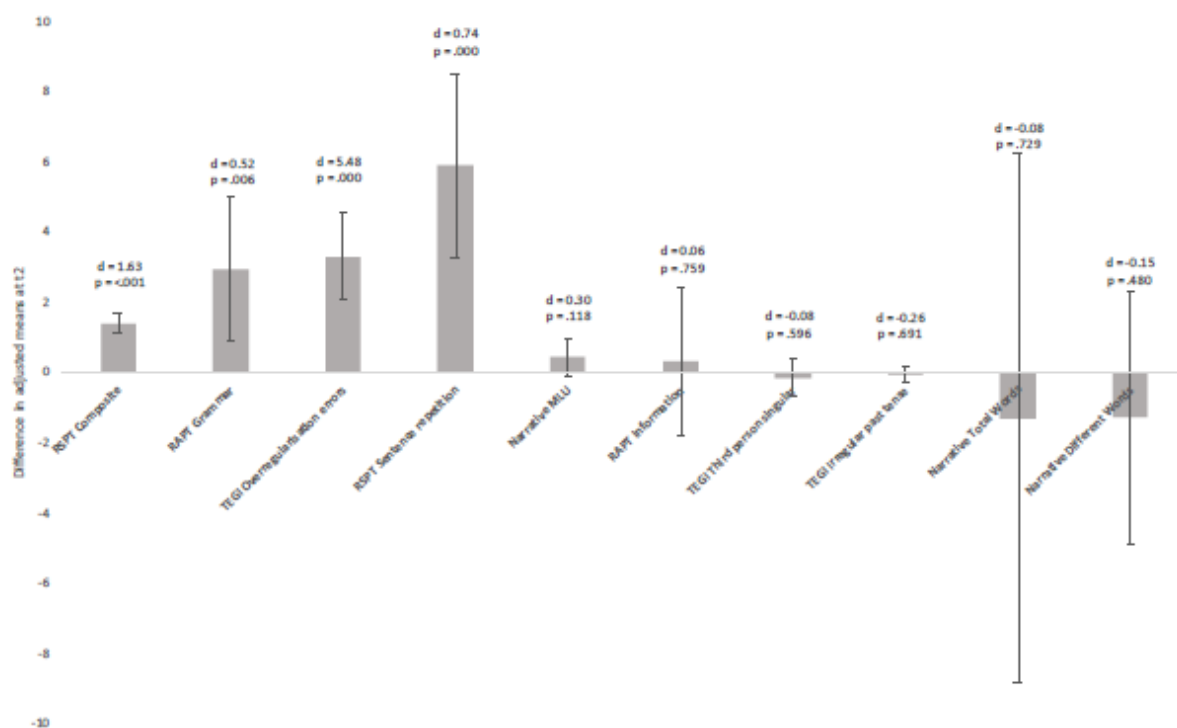


Figure 3. Scatter plot showing composite raw scores for the two groups on four measures of regular simple past tense marking at time 1 (before intervention) and time 2 (immediately after intervention for the Intervention group). The solid and dashed lines are the regression functions relating time 1 to time 2 scores for the two groups. The light coloured lines indicate the 95% confidence intervals for the predicted means for each group.

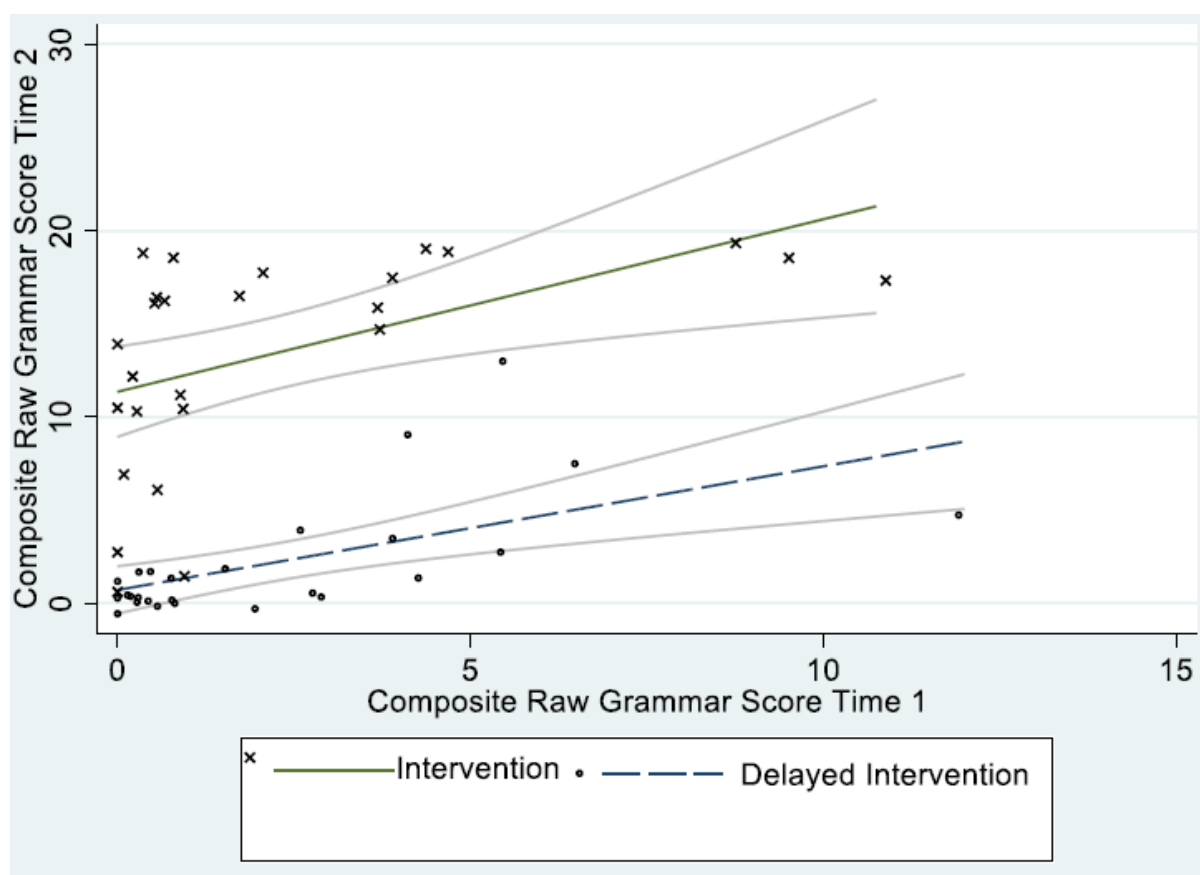
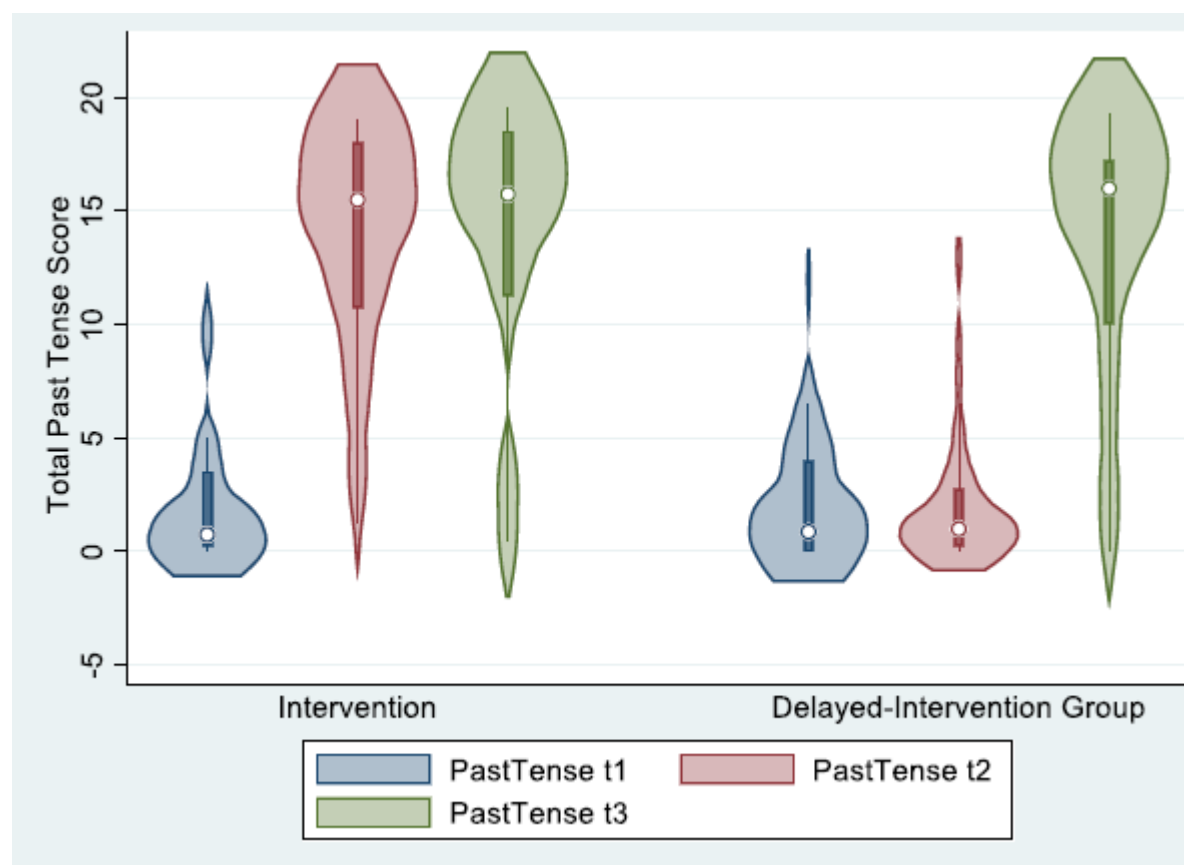


Figure 4. Violin plot showing composite raw scores on four measures of regular simple past tense marking as a function of time and group. The hollow circle at each time point indicates the median value, the dense bar represents the interquartile range, and the spikes represent the upper and lower adjacent values.



Appendix 1. An overview of the structure of sessions throughout each week of the intervention period

Table 1 Mean raw scores (standard deviation) on all measures at all time points in the study, t1 prior to intervention, t2 post intervention and t3 follow up. The effect size at each time point is calculated as the difference between groups divided by the pooled standard deviation at that time point (Cohen's d), a positive value of d indicates an advantage for the Intervention group compared to the Delayed Intervention group. 95% confidence intervals are given for each value of d ; where the confidence interval does not include zero the difference is significant (indicated by *).

	Intervention Group				Cohen's d
	Intervention		Delayed intervention		
	n = 26		n = 26		
	M	SD	M	SD	
<i>Age (months)</i>					
t1	106.00	15.73	108.81	16.08	
t2	110.50	15.79	114.50	15.77	
t3	113.32	16.08	117.54	15.87	
<i>Baseline assessments (t1)</i>					
Ravens CPM	13.73	3.77	12.12	2.79	
ROWVT	60.23	9.44	62.15	10.15	
EOWVT	53.69	13.33	54.69	12.22	
TROG-II	19.69	10.88	19.5	7.91	
CELF-4 RS	3.23	5.32	2.85	3.86	
TEGI Phon. Probe	19	2.59	17.38	5.3	
YARC Word reading	19.31	12.20	18.62	10.84	
YARC LSK	13.5	4.44	13.15	4.53	
<i>Intervention test battery (t1, t2, t3)</i>					

PAST TENSE LEARNING

Renfrew Action Picture Test (RAPT)

RAPT Grammar

t1	8.5	5.68	10.27	6.70	-.28 [-.83, .26]
t2	13.17	6.53	11.69	5.88	.24 [-.31, .78]
t3	15.24	6.76	12.71	6.98	.37 [-.19, .92]

RAPT Information

t1	21.63	6.59	21.73	5.98	-.02 [-.56, .53]
t2	24.06	4.99	23.79	5.26	.05 [-.49, .60]
t3	26.66	5.80	26.79	4.57	-.02 [-.57, .52]

Test of Early Grammatical Impairment (TEGI)

TEGI Past Tense Probe – regular verbs

t1	1	2.21	1.27	1.82	-.13 [-.68, .41]
t2	7.12	3.15	1.12	1.70	2.37 [1.65, 3.07]*
t3	7.08	3.91	7.04	3.68	.01 [-.54, .56]

TEGI Past Tense Probe – irregular verbs

t1	0.42	0.64	0.27	0.53	.26 [-.29, .81]
t2	0.35	0.69	0.35	0.63	0 [-.54, .54]
t3	0.48	0.92	0.24	0.52	.32 [-.24, .88]

TEGI Past Tense Probe – overregularisation errors

t1	0.08	0.27	0.27	0.83	-.31 [-.86, 2.06]
t2	3.69	2.90	0.5	1.14	1.45 [.83, 2.05]*
t3	3.92	2.63	3.6	2.29	.13 [-.43, .68]

TEGI Third Person Singular Probe

t1	0.92	2.13	0.81	1.52	.06 [-.48, .61]
t2	0.88	2.14	0.92	1.44	-.02 [-.56, .52]
t3	1.64	2.80	1.24	1.69	.17 [-.38, .73]

PAST TENSE LEARNING

Bespoke Regular Simple Past Tense Probes (RSPTP)

Taught RSPTP

t1	4.73	7.37	4.62	7.10	.02 [-.53, .56]
t2	30.23	11.16	4.12	7.15	2.79 [2.01, 3.55]*
t3	28.6	13.63	28.19	13.48	.03 [-.52, .58]

Untaught RSPTP

t1	2.5	3.15	2.35	3.19	.05 [-.50, .59]
t2	12.81	6.53	2.23	3.56	2.01 [1.33, 2.68]*
t3	13.44	7.23	12.69	6.32	.11 [-.44, .66]

RSPT Sentence Repetition

t1	17.62	6.79	15.96	7.64	.23 [-.32, .77]
t2	24.04	5.92	17.08	7.21	1.06 [.47, 1.63]*
t3	23.36	6.85	21.5	7.66	.26 [-.30, .81]

Narrative Retell

Retell TNW

t1	43.42	20.00	40.27	16.36	.17 [-.37, .72]
t2	51.27	21.16	49.62	22.31	.08 [-.47, .62]
t3	52.6	21.66	54.12	25.47	-.06 [-.61, .48]

Retell NDW

t1	27.35	10.31	25.96	9.07	.14 [-.40, .69]
t2	30.31	10.19	30.38	10.81	-.01 [-.55, .54]
t3	31.76	10.68	32.04	11.41	-.03 [-.57, .52]

Retell MLU

t1	3.76	1.46	3.91	1.59	-.08 [-.62, .46]
t2	4.46	1.75	4.13	1.63	.20 [-.35, .74]
t3	4.45	1.68	4.38	1.59	.04 [-.51, .59]

Retell Past Tense

PAST TENSE LEARNING

t1	0.81	1.36	0.62	0.90	.17 [-.38, .71]
t2	3.65	2.35	1.27	1.34	1.25 [.65, 1.84]*
t3	3.72	2.61	3.62	2.70	.04 [-.51, .51]

RS=recalling sentences, Phon=phonological, LSK=letter sound knowledge, overregularisation errors=regular rule applied to irregular verbs (e.g. digged), TRSPTP=taught regular simple past tense probe, URSPTP=untaught regular simple past tense probe, RSPTSr=regular simple past tense sentence repetition, TNW=total number of words, NDW=number of different words, MLU=mean length of utterance. Data for one child are missing for t3 on all intervention measures in the Intervention Group, and for one child on t3 TEGI probes in the Delayed Intervention group