

1 **Explicit grammar intervention in young school-aged children with Developmental**
2 **Language Disorder: an efficacy study using single case experimental design**

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19 The authors declare there are no relevant conflicts of interest.

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23 **Abstract**

24 **Purpose:** This study evaluated the efficacy of an explicit combined metalinguistic training
25 and grammar facilitation intervention aimed at improving regular past tense marking for nine
26 children aged 5;10-6;8 years with DLD.

27 **Method:** This study used an ABA across participant multiple baseline single case
28 experimental design. Participants were seen 1:1 twice a week for 20-30 minute sessions for
29 10 weeks and received explicit grammar intervention combining metalinguistic training using
30 the SHAPE CODING™ system with grammar facilitation techniques (a systematic cueing
31 hierarchy). In each session, 50 trials to produce the target form were completed, resulting in a
32 total of 1000 trials over 20 individual therapy sessions. Repeated measures of morphosyntax
33 were collected using probes, including trained past tense verbs, untrained past tense verbs,
34 third person singular verbs as an extension probe, and possessive 's as a control probe.
35 Probing contexts included expressive morphosyntax and grammaticality judgement. Outcome
36 measures also included pre-post standard measures of expressive and receptive grammar.

37 **Results:** Analyses of repeated measures demonstrated significant improvement in past tense
38 production on trained verbs (8/9 children) and untrained verbs (7/9 children) indicating
39 efficacy of the treatment. These gains were maintained for five weeks. The majority of
40 children made significant improvement on standardised measures of expressive grammar (8/9
41 children). Only 5/9 children improved on grammaticality judgement or receptive measures.

42 **Conclusion:** Results continue to support the efficacy of explicit grammar interventions to
43 improve past tense marking in early school-aged children. Future research should aim to
44 evaluate the efficacy of similar interventions with group comparison studies, and determine
45 whether explicit grammar interventions can improve other aspects of grammatical difficulty
46 for early school-aged children with DLD.

47 Developmental Language Disorder (DLD) refers to children who experience language

48 difficulties in the absence of known biomedical conditions or acquired brain injury (Bishop,
49 Snowling, Thompson, Greenhalgh, & CATALISE-consortium, 2017). Compared to typically
50 developing peers, children with DLD present with particular difficulties in morphosyntactic
51 skills, such as the use (Rice, Wexler, & Hershberger, 1998) and judgement of grammatical
52 morphemes associated with tense (Rice, Wexler, & Redmond, 1999).

53 Finiteness marking is challenging for children with DLD (see Leonard, 2014 for a
54 review). Finiteness refers to the obligatory marking of verbs indicating subject-verb
55 agreement and tense, including affixation of morphemes *-ed* (e.g. *the girl walked*) and *-S* (e.g.
56 *the girl walks*) to verbs for past- and present-tense, respectively. Within English and cross-
57 linguistically, finiteness is a quality of well-constructed clauses (Dale, Rice, Rimfeld, &
58 Hayiou-Thomas, 2018). There is evidence supporting disordered finiteness as a distinct
59 aetiological construct and predictive marker of language growth for DLD (Bishop, Adams, &
60 Norbury, 2006). Children's grammar difficulties are a primary source of parental concern
61 when considering referral for clinical services (Bishop & Hayiou-Thomas, 2008).

62 **Grammar interventions**

63 Treatment for DLD aims to accelerate language growth and remove barriers to
64 functional communication by harnessing strengths (Justice, Logan, Jiang, & Schmitt, 2017).
65 Ebbels's (2014) review indicates an emerging evidence-base for the effectiveness of grammar
66 intervention for school-aged children with DLD. Current evidence is parsed into implicit and
67 explicit approaches to intervention. According to Ebbels's framework, *implicit interventions*
68 target production and understanding of grammar using grammar facilitation techniques
69 implicitly by responding to children's errors in a naturalistic way (Fey, Long, & Finestack,
70 2003). Children's learning and the knowledge acquired are not necessarily associated with
71 awareness. *Explicit interventions* target increased awareness of the goals of intervention with
72 a pre-established concept of the criteria for success: learning is conscious and deliberate, and

73 information can be recalled on demand (Shanks, Lamberts, & Goldstone, 2005). Within each
74 approach to intervention, specific techniques are used to improve acquisition of grammar.

75 **Implicit interventions using grammar facilitation.** Intervention and scaffolding
76 techniques used in implicit approaches are described as *grammar facilitation* (e.g. Fey et al.,
77 2003), which aims to facilitate the acquisition of grammar by increasing the frequency and
78 quality of target forms in input and output. Greater exposure to and opportunities to learn and
79 use language theoretically accelerates the likelihood of language growth (Leonard, 2014).
80 Studies have empirically tested grammar facilitation techniques supporting their use with
81 expressive morphosyntax targets, including imitation (Nelson, Camarata, Welsh, Butkovsky,
82 & Camarata, 1996), modeling (Weismer & Murray-Branch, 1989), focused stimulation
83 (Leonard, Camarata, Brown, & Camarata, 2004), and conversational recasting (see Cleave,
84 Becker, Curran, Van Horne, & Fey, 2015 for a review). Recently, Van Horne, Fey and
85 Curran (2017) reported on a primarily implicit intervention, in which procedures included a
86 combination of sentence imitation, observational modelling, storytelling and focused
87 stimulation, recasting, and cueing for incorrect responses. All 18 four to 10 year old children
88 with DLD enrolled in the study improved their use of regular past tense. Notably, as
89 participants were dismissed from the study following 36 sessions, many still did not achieve
90 mastery of the intervention target. In general, outcomes following implicit intervention are
91 favourable for morphosyntax in preschool-aged children (Leonard, 2014), however, mastery
92 of intervention targets is rarely reported.

93 **Explicit intervention using metalinguistic training.** Difficulties with morphosyntax
94 often persist into school age for children with DLD (Bishop, Bright, James, Bishop, & Van
95 der Lely, 2000). An alternative approach may be required because children with DLD may
96 have difficulty learning grammar through implicit grammar facilitation. *Metalinguistic*
97 *training* aims to improve children's learning of the rules of grammar by creating conscious

98 awareness of grammar through explicit metacognitive teaching (Ebbels, 2014) allowing
99 children to actively reflect on language targets. Meta-awareness is enhanced, so rules of
100 grammar are learned explicitly in a compensatory way.

101 Metalinguistic techniques can be used explicitly to teach grammar through
102 metacognitive strategies using visual supports and graphic organisers (Ebbels, 2014). The
103 SHAPE CODING™ system is designed to explicitly teach oral and written syntax to children
104 with language disorder (Ebbels, 2007). Ebbels, van der Lely and Dockrell (2007) compared
105 use of the SHAPE CODING™ system with semantic therapy and a no treatment control
106 group with 27 children aged between 10 and 16;1 with DLD. The authors concluded that the
107 SHAPE CODING™ system is a viable and efficacious treatment approach to improve verb-
108 argument structure in older school-aged children. Although evidence for improvement in
109 grammar comprehension is mixed (e.g. Zwitserlood, Wijnen, van Weerdenburg, &
110 Verhoeven, 2015), children may be able to consciously reflect upon the rules of grammar
111 through explicit interventions in the presence of receptive language difficulties to improve
112 understanding, especially older children (Ebbels, Maric, Murphy, & Turner, 2014).

113 Grammar intervention approaches effective for children above eight years should be
114 tested with younger children to address the concerning gap in evidence for this age group
115 (Ebbels, 2014). Further, Ebbels suggested there may be benefit to integrating therapy
116 techniques to include grammar facilitation and metalinguistic training in a range of activities
117 (e.g. Fey et al., 2003). Combined approaches are yet to be explored extensively.

118 **Combined intervention approaches.** In an early-stage efficacy study, Finestack
119 (2018) used a combined implicit/explicit metalinguistic approach compared to an implicit
120 approach to teach novel morphemes to six to eight year old children with DLD. The
121 combined approach was more efficacious than the implicit approach, with gains being

122 maintained and generalised. In a randomised control trial of 31 preschool-aged children,
123 Smith-Lock, Leitão, Prior and Nickels (2015) used explicit teaching principles combined
124 with a systematic cueing hierarchy, which was effective in improving use of expressive
125 morphosyntax when compared to conversational recasting alone. Importantly, the study
126 included a metalinguistic component where children in the explicit group were aware of the
127 therapeutic goal (Smith-Lock et al., 2015). Kulkarni, Pring and Ebbels (2013) conducted a
128 clinical evaluation of the SHAPE CODING™ system combined with elicited production and
129 recasting to improve the use of past tense for two children aged 8;11 and 9;4 with DLD. Both
130 made significant gains in their use of the target structure.

131 Although grammar facilitation is generally considered implicit (Ebbels, 2014; Fey et
132 al., 2003), there is evidence that the techniques can be used explicitly. In a pilot efficacy
133 study, Calder, Claessen and Leitão (2018) combined the SHAPE CODING™ system with the
134 systematic cueing hierarchy detailed in Smith-Lock et al. (2015) to improve grammar in three
135 children aged seven years with DLD. Importantly, systematic cueing as a grammar
136 facilitation technique in this study was *explicit*. Cues ranged from least to most support, and
137 there was a focus on teaching correct production of grammar through errors to avoid the child
138 perceiving the error to be semantic in nature, as may be the case when using conversational
139 recasting without stating the goal of intervention first. The findings provided early evidence
140 supporting the use of combined intervention approaches to improve receptive and expressive
141 grammar, particularly production of regular past tense following five weeks of intervention.
142 Notably, participants made gains in expressive grammar following only 10 intervention
143 sessions across five weeks, which is markedly shorter duration than reported in many
144 intervention studies. However, the authors acknowledge that including measures of teaching,
145 maintenance and generalisation (e.g. Finestack, 2018) would have broadened understanding
146 of treatment effects, and that a longer period of intervention might be necessary.

147 **Grammar interventions in clinical practice.** Recently, Finestack and Satterlund
148 (2018) reported on a national survey of speech language pathology practice in the US. Past-
149 tense verb production was a common intervention goal for practitioners in both early (40%)
150 and elementary education settings (60%). Interestingly, overall between 60-70% used explicit
151 presentations as an intervention procedure, despite relatively little investigation in this area
152 until recently. Therefore, it appears explicit instruction to improve past tense may not only be
153 supported by an emerging evidence-base, but is also frequently used in clinical practice.

154 **The current study**

155 For early school-aged children, preliminary data suggest that explicit combined
156 metalinguistic and grammar facilitation approaches are efficacious in treating the use of tense
157 marking and for improving receptive grammar more generally (Calder et al., 2018). Building
158 on early stage studies of treatment efficacy is required to determine if treatment procedures
159 are considered evidence-based. Fey and Finestack (2008) outline the need for a programmatic
160 approach to pursuing intervention research, specifically noting the value of small scale
161 studies aimed at exploring and identifying specific components of intervention approaches
162 and their effects on specific populations. This study forms a part of a programme of research
163 to design, develop and evaluate the efficacy of an explicit combined grammar intervention in
164 line with Robey's Phases of Clinical Research (Robey, 2004). We report on a range of
165 measures to evaluate the efficacy of explicit intervention to improve grammar. Single case
166 experimental design (SCED) methodology was used to test the following confirmatory
167 hypotheses and is reported as per the Single-Case Reporting Guideline in Behavioural
168 Interventions (SCRIBE) (Tate et al., 2016):

- 169 1. For young school-aged children (specifically, 5;10-6;8 years) with DLD, there will be a
170 significant treatment effect on trained past tense verbs, and a generalised effect to

171 untrained verbs across 20 sessions of explicit intervention combining metalinguistic and
172 grammar facilitation techniques.

173 2. These children will improve significantly on pre-post standardised measures of expressive
174 and receptive grammar.

175 **Method**

176 **Research Design**

177 **Design.** The current study was an ABA across participant multiple baseline single
178 case experimental design (SCED) including a minimum of five data points (i.e. sessions) for
179 each phase (Kratochwill et al., 2012). Multiple baselines were conducted for varied durations
180 across participants, and introduction of treatment to participants was staggered. Repeated
181 measures were collected throughout the intervention phase and post-treatment maintenance
182 phase (Dallery & Raiff, 2014), including the target behaviour (past tense verbs), an extension
183 of the targeted behaviour (third person singular verbs) and a control behaviour (possessive
184 's). This design is noted for robustness regarding strengths of internal validity and external
185 validity when compared to other SCEDs (Tate, et al., 2016). As a Phase I-II study, we
186 replicated and built on findings from Calder et al. (2018) by refining intervention protocols,
187 determining optimal dosage and evaluating duration of therapeutic effect (Robey, 2004).

188 **Randomisation.** To improve internal validity further, participants were randomly
189 assigned to one of three pre-determined staggered onset to intervention conditions. To ensure
190 concealed allocation, participants were assigned a code which was entered into a random list
191 generator by a blinded researcher. Participants received: five (P1, P3, P8), seven (P5, P7, P9)
192 or nine (P2, P4, P9) pre-intervention baseline sessions over as many weeks; 20 intervention
193 sessions over 10 weeks, and; five post-intervention sessions to evaluate maintenance.
194 Participants were also randomised to grammaticality conditions described below.

195 **Blinding.** Participant caregivers and teachers were aware children were receiving
196 grammar intervention but were blinded to the intervention target. Post-intervention measures
197 were collected via blinded assessment using trained student speech-language pathologists.

198 **Participants**

199 **Selection criteria.** Participants included nine early school-aged children diagnosed
200 with DLD. The inclusion criteria were: aged between 5;6 and 7;6; English as a primary
201 language, and; grammar difficulties associated with DLD. Exclusionary criteria included: a
202 neurological diagnosis, a cognitive impairment, and hearing outside normal limits.
203 Participants were recruited from a specialised educational program for students diagnosed
204 with DLD. Ethical approval for the study was obtained from the Curtin University Human
205 Research Ethics Committee (Approval number: HRE2017-0835) and the Western Australian
206 Department of Education. The principal consented school participation and then provided
207 information letters and consent forms to the parents/carers of potential participants identified
208 by speech-language pathologists and teachers employed at the educational program. Parents
209 returned the completed consent forms if they wished their child to participate. The study
210 reached capacity at nine participants so we could achieve three replications over three
211 baseline conditions as per reporting standards (Kratochwill et al., 2012).

212 **Participant characteristics.** The participants' school enrolment package was
213 accessed, including the assessment protocol and the most recent standardised assessment
214 scores available. Data included Clinical Evaluation of Language Fundamentals Preschool- 2
215 (Wiig, Secord, & Semel, 2004); a test of non-verbal IQ, and; a comprehensive exploration of
216 previous medical history to identify contributing factors to language difficulties, such as

217 Table 1

218

219 *Demographic information*

220

Participant ID	Sex	Age at enrolment to school (year; month)	Current year at specialised educational program	Age at initial assessment for study (year; month)
P1	Male	4;0	3rd	6;3
P2	Male	3;11	3rd	6;2
P3	Male	4;7	2nd	5;10
P4	Male	5;4	3rd	6;8
P5	Male	5;2	2nd	6;6
P6	Female	5;11	1st	6;2
P7	Male	5;3	2nd	6;7
P8	Male	3;8	3rd	6;0
P9	Male	4;9	2nd	6;1

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227 acquired neurological damage, or hearing loss. These factors combined are considered
228 evidence of a diagnosis for DLD (Bishop, Snowling, Thompson, Greenhalgh, & CATALISE-
229 consortium, 2016). Participants then passed a hearing acuity test. All participants passed the
230 Phonological Probe from the Test of Early Grammatical Impairment (Rice & Wexler, 2001)
231 for articulation of phonemes necessary for morphosyntactic production targets.

232 All demographic information is presented in Table 1. Participants included eight
233 males and one female aged between 5;10 and 6;8 at initial assessment. Ages at enrolment to
234 the specialist school varied from 3;8 years to 5;11. P1, P2, P4 and P8 were in their third year
235 of placement at the school; P3, P5, P7 and P9 were in their second, and; P6 was in her first.

236 **Measures**

237 **Repeated Measures.**

238 Repeated measures of morphosyntax were collected at every data point using various
239 probes, including: trained probes, untrained probes, an extension probe and a control probe
240 (elaborated in the following sections). Probing contexts included both expressive
241 morphosyntax and grammaticality judgement. Grammaticality judgement was selected as a
242 method of measuring grammatical progress, as there is evidence performance on such tasks
243 mirrors production tasks (Rice et al., 1998; 1999). As grammaticality judgement is a clinical
244 marker of DLD (Rice et al., 1999; Dale et al., 2018), identification of grammatically correct
245 sentences in the studied participants was expected to be below chance levels of accuracy prior
246 to intervention.

247 Trained probes. Regular past tense (*-ed*) repeated measures of trained verbs were
248 probed in two conditions: 12 *-ed* verbs trained within sessions were measured, and; 12 *-ed*
249 verbs from the previous session were measured. All *-ed* verbs were predetermined at the
250 outset of intervention and selected based on their suitability to intervention activities. We also

251 chose verbs that were not in the Grammar Elicitation Test (GET; described below; Smith-
252 Lock, Leitão, Lambert, & Nickels, 2013) to allow comparison between trained and untrained
253 verbs. These probes were administered during the intervention phase at the end of session 2
254 (i.e. data point B1 the first week of intervention), and every even session thereafter.

255 ***Untrained probes.*** Repeated measures of untrained expressive morphosyntax probes
256 were selected from an adapted version of the GET. This experimental test was designed to
257 elicit multiple instances of specific expressive morphosyntax targets, including 30 items
258 probing the treated grammatical structure (-ed). Repeated measures were also developed for a
259 grammaticality judgement task including 30 -ed probes. Videos of actions depicting the
260 declarative clauses containing -ed were created as stimuli for untrained probes.

261 Accompanying audio for each task item, both grammatical and ungrammatical (e.g. *The girl*
262 *painted a picture.* vs. *The girl paint* a picture.*) was recorded by an adult female with an
263 Australian accent, blinded to the purpose of research. Each video with corresponding audio
264 was embedded into a Microsoft PowerPoint presentation. Participants wore Sony noise-
265 cancelling headphones during administration and were required to decide if the sentence
266 ‘sounded right’ by pressing ‘yes’ or ‘no’ on a tablet app. Items were counterbalanced for
267 grammaticality so participants did not receive the same combination of
268 grammatical/ungrammatical items, and there was no pattern in presentation of
269 grammatical/ungrammatical items to counteract a priming effect.

270 Complete sets of 30 untrained -ed verbs were probed pre- and post-intervention. Sets
271 were randomised for administration at the initial assessment (Timepoint 1), one week prior to
272 intervention commencing (Timepoint 2), one week following intervention (Timepoint 3) and
273 five weeks following cessation of intervention (Timepoint 4). Both expression and
274 grammaticality judgement were assessed.

275 Reduced randomised sets were generated for each other data point using nine
276 expressive probes and 12 grammaticality judgement probes. All possible allomorphs were
277 included (i.e. [d], [t] and [əd]) and equally distributed. Probes were administered via laptop
278 during the pre-intervention baseline phase, at the beginning of session 3 (i.e. data point B2 in
279 the second week of intervention) and every odd session thereafter during the intervention
280 phase, and in the post-intervention maintenance phase.

281 **Extension probes.** Expressive repeated measures of third person singular (3S) served
282 as an extension of the treated structure. Items included 30 probes and were taken from the
283 GET. A grammaticality judgement task was also developed as per the untrained *-ed* probes
284 (e.g. *The man sneezes.* vs. *The man sneeze**). 3S was considered an extension measure due to
285 the structure's relative complexity compared to *-ed*, since bare stem forms are grammatical
286 when used with first person subject pronouns or plural subject nouns (e.g. *I like ice-cream* vs.
287 *The boys like ice-cream* vs. *The boy likes ice-cream*). We also expected there might be
288 improvement in 3S due to the frequent instances of input during therapy (see Intervention
289 section) and increased awareness of the need for tense marking.

290 **Control probes.** Similarly, expressive repeated measures of possessive 's ('s) served
291 as a control probe. Items included 30 probes and were taken from the GET. As above, a
292 grammaticality judgement task was developed (e.g. *The spider is living on a leaf. This is the*
293 *spider's leaf.* vs. *The spider is living on a leaf. This is the spider* leaf.*). For 's, still images of
294 nouns depicting ownership were retrieved from copyright free image sources. 's was
295 considered a control as this noun possession was not taught as part of therapy and therefore
296 should remain stable throughout the intervention period.

297 For extension and control probes, all possible allomorphs were included (i.e. [s], [z],
298 [əz]) and equally distributed. Randomised sets of 9 expressive and 12 grammaticality

299 judgement items were generated and administered as per the untrained *-ed* probes during pre-
300 intervention, intervention, and post-intervention phases.

301 **Pre-post.**

302 The Structured Photographic Expressive Language Test 3rd Edition (SPELT-3)
303 (Dawson, Stout, & Eyer, 2003) and the Test of Reception of Grammar 2nd Edition (TROG-2)
304 (Bishop, 2003) were administered both pre- and post-intervention as expressive and receptive
305 standardised grammar measures, respectively. The SPELT-3 measures expressive
306 morphosyntax using 54 items across a range of structures and was normed on children aged
307 four to nine years. To address discriminant accuracy of the test, Perona, Plante and Vance
308 (2005) determined 90% sensitivity and 100% sensitivity at 95 cutoff (-0.33SD). This cutoff
309 score was used for the current study based on the recommendation, although it is noted that
310 while other studies applied this cutoff with older children (e.g. Van Horne et al., 2017),
311 Perona et al. (2005) sampled children aged four to five years. The TROG-2 test measures a
312 total of 20 different grammatical structure contrasts and was normed on children aged four to
313 16. Discriminant accuracy was evaluated on a sample of 30 children aged 6;2-10;11 which
314 confirmed the test is sensitive to identifying communication difficulties in children (Bishop,
315 2003). Both tests have strong reliability and appropriate validity.

316 **Reliability.**

317 A blinded researcher scored 20% of all measures audio and video recorded throughout
318 the study. Inter-rater reliability for experimental measures was calculated using intraclass
319 correlation coefficients (ICC) using absolute agreement and single measures in a two-way
320 mixed effects model. Interpretation of ICC values are as follows: <.40 = poor; .40-.59 = fair;
321 .60-.74 = good, and; .75-1.00 = excellent (Cicchetti, 1994). For trained *-ed* probes, the ICC
322 for expressive measures was .879 and ICC for grammaticality judgement was .977. ICC for

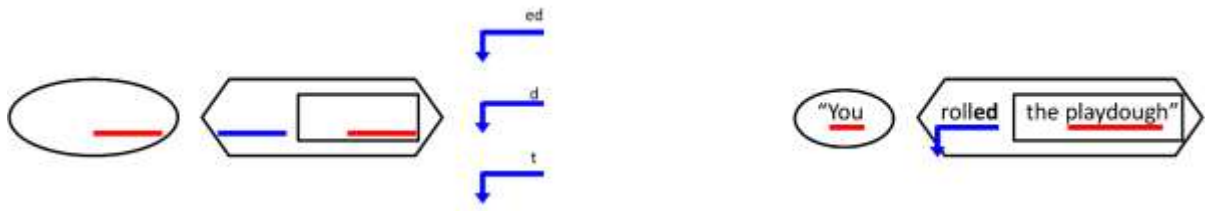
323 expressive untrained *-ed*, 3S and *'s* probes was .937, and ICC for the grammaticality
324 judgement of untrained *-ed*, 3S and *'s* was .985. Therefore, excellent agreement was observed
325 across all experimental measures.

326 **Intervention**

327 All intervention sessions were videotaped and carried out in a quiet space at the site of
328 the educational program. Procedures were similar to those reported by Calder et al. (2018)
329 and are explained within the model suggested by Warren, Fey, and Yoder (2007) for
330 describing treatment intensity. The dose was 50 trials within 20-30 minute sessions; dose
331 form was explicit intervention combining metalinguistic training using the SHAPE
332 CODING™ system (Ebbels, 2007) with a systematic cueing hierarchy (Smith-Lock et al.,
333 2015); dose frequency was twice a week; total intervention duration was 10 weeks, and;
334 cumulative intervention intensity was (50 trials x 2 times per week x 10 weeks), resulting in a
335 total of 1000 trials over 20 individual therapy sessions through roughly 7-10 hours of therapy.
336 This is double the intervention duration in the pilot study (Calder et al., 2018), where authors
337 suggested that participants may demonstrate larger treatment effects following a longer
338 duration. Training of morphosyntax was embedded within engaging and naturalistic activities
339 suited to early school-aged children, including playdough, board games, and playing with
340 puppets, and farm and sea creature manipulatives. Target morphemes were presented in
341 syntactic structures as they occurred felicitously within these activities. The first author
342 (SDC), a trained speech-language pathologist (SLP), delivered all intervention.

343 Each session began with a short recap of the aims: to say WHAT DOING words
344 (verbs) that have already happened, and to add the sounds ([d], [t], [əd]) onto the end of those
345 words. Next, the SLP would direct the child's attention to the laminated shapes and arrows
346 used as a visual organiser throughout session activities. See Figure 1 for essential shapes,

347



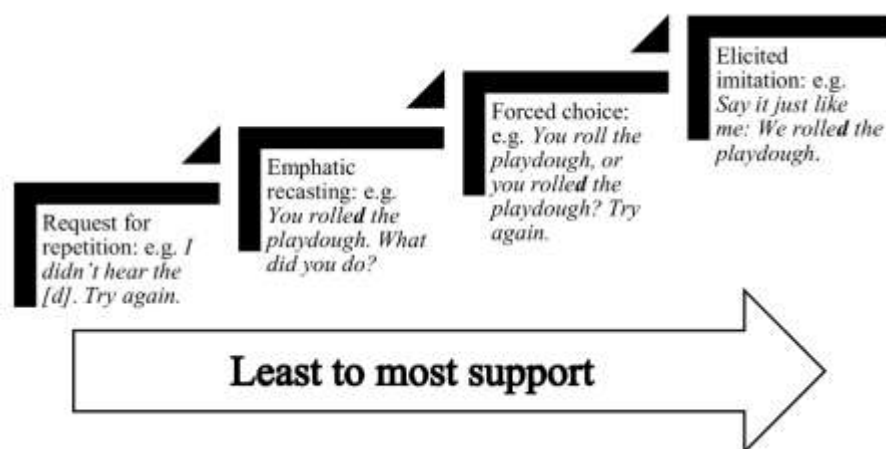
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349 *Figure 1.* Visual depiction of visual cues used during intervention phase.

350 including the oval (subject noun phrase WHO/WHAT?), the hexagon (verb phrase WHAT
 351 DOING?) and the rectangle (object noun phrase WHO/WHAT?). Additional visual cues
 352 included three separate laminated cards that depicted a ‘left down arrow’ to depict *-ed*, and an
 353 orthographic representation of the allomorphs (i.e. ‘d’ for [d], ‘t’ for [t], and ‘ed’ for [əd]).
 354 The SLP said, “*Last time, we used our shapes and arrows to help us. Like this: ‘We move our*
 355 *shapes and arrows. What did we do? We moved* [bring ‘d’ arrow into the WHAT DOING?
 356 hexagon] *our shapes and arrows. The [d] at the end of moved lets us know it’s already*
 357 *happened.*” The participant was reminded, “*I (the SLP) will say what we do in the session*
 358 *(i.e. present tense) and you will say what we did (i.e. past tense)*”. This was followed by two
 359 activities which were designed to give the participants ample opportunities to produce *-ed*
 360 verbs in response to an interrogative (e.g. *What did you do?; Did you just VERB? Tell me...*).

361 Each activity began with explicit instruction of how to apply *-ed* inflection, using one
 362 exemplar from each of the allomorphic categories. Within each activity, there were
 363 approximately 25 opportunities for the child to respond to an interrogative (e.g. *You roll the*
 364 *playdough! What did you do?*) using *-ed* verbs while the SLP gestured to the shapes and
 365 arrows (see Figure 1). The child was therefore encouraged to respond using a Subject-Verb-
 366 Object syntactic frame, consistently. If the child responded with an unmarked verb (i.e. bare
 367 stem) or overgeneralised form (e.g. *playded*), s/he was supported with a systematic cueing
 368 hierarchy moving from least to most support outlined in Figure 2. As much as possible, verbs

369 were blocked according to allomorphs and presented from least to most difficult (i.e.
 370 [d]→[t]→[əd]) in accordance with Leonard (2014) and Marshall and van der Lely (2006). At
 371 the end of every activity, the SLP recapped what the participant had learned using the shapes
 372 and arrows, and comprehension questions. For example, if the target sentence had been ‘*I*
 373 *rolled playdough*’, the SLP would gesture to the WHO?/WHAT? oval and ask, “*WHO rolled*
 374 *the playdough?*” Then gesture to the WHAT DOING? hexagon while bringing down the ‘d’
 375 left down arrow and ask, “*What DID you DO?*”, and finally gesture to the WHO?/WHAT?
 376 rectangle and ask, “*WHAT did you roll?*” Plausible responses to all of these questions are ‘*I*
 377 *rolled the playdough*’, giving further opportunity to reinforce production using a consistent
 378 syntactic frame. If an error occurred, the same systematic cueing hierarchy described above
 379 was employed. The shapes and arrows were then removed, and the interrogative (*What DID*
 380 *you DO?*) was repeated without visual support for an exemplar from all three allomorphic
 381 categories, reinforcing internalisation of the grammatical rule. If a child had achieved 80%
 382 success over three sessions on any measure, ‘silly Sentences’ were introduced; a
 383 metalinguistic sub-activity whereby three sentences were said, either grammatically or
 384 ungrammatically (i.e. *-ed* morphemes were either included or omitted), and the child would
 385 decide if the sentence ‘sounded right’.



387 *Figure 2. Systematic cueing hierarchy used when child produced the target verb in error.*

388 These procedures were repeated for a second activity, giving 50 opportunities to use
389 *-ed* inflection during the activity which was bookended with explicit teaching and
390 comprehension questions using three exemplars from each allomorphic category. At the end
391 of each session, the child was reminded of the goal of the session, and why it is important to
392 say the sounds at the end of ‘*WHAT DOING?*’ words that have already happened, and also to
393 listen out for those sounds.

394 **Procedural fidelity.**

395 A blinded researcher scored 20% of videotaped sessions on percentage accuracy using
396 *a priori* established criteria for intervention procedures. A total of 19 items were scored for
397 sessions (see Appendix A for a checklist for scoring intervention procedure fidelity). Note, if
398 children were introduced to ‘silly Sentences’, sessions were scored against an additional two
399 (total 21) items. Intra-observer agreement was calculated using ICC. The average score was
400 97.1% for percentage accuracy, and ICC for treatment procedures was .996.

401 **Analysis**

402 **Single subject analyses.** Treatment effects of teaching, generalisation and
403 maintenance through repeated measures of morphosyntax were statistically evaluated using
404 *Tau-U* by combining non-overlap and trend of data (Parker, Vannest, Davis, & Sauber, 2011)
405 across all phases and data points. *Tau-U* uses Kendall’s *S* to interpret significance testing and
406 outputs *p* values. Raw scores on probes were converted to percentage correct. Baselines were
407 contrasted using the *Tau-U* online calculator (Vannest, Parker, Gonen, & Adiguzel, 2016),
408 and the *Tau* value was checked for trend of baseline in pre-intervention and post-intervention
409 phases. For pre-intervention baseline, *Tau* values above 0.40 (increasing trend) or below
410 -0.40 (decreasing trend) were deemed unstable and corrected, as recommended by Parker et
411 al. (2011). This was repeated for all applicable baseline versus intervention contrasts. Finally,

412 phase contrasts were aggregated to provide an omnibus effect size for study participants,
413 where, using Cohen's standard, 0.2 is small, 0.5 is medium and 0.8 is large.

414 To evaluate performance on the full sets of untrained *-ed* verbs, a concurrent within-
415 group approach was used (e.g. Zwitserlood et al., 2015) where Friedman non-parametric two-
416 way analysis of variance (ANOVA) tested differences between Timepoint 1 and 2 pre-
417 intervention, and Timepoint 3 and 4 post-intervention scores. Participant scores determined a
418 group mean and standard deviation in expressive and grammaticality judgement probes
419 within each Timepoint. Post-hoc Wilcoxon sign-rank tests made pairwise comparisons
420 between testing points. These statistics were computed using IBM SPSS Version 25.

421 Kratochwill et al. (2012) outline standards for analysis of repeated measures via
422 visual inspection to report on a functional relation between dependent and independent
423 variables, which includes comments on level, trend and variability within phases, and
424 comments on immediacy, overlap and consistency between phases. For the current study,
425 within phase level performance was evaluated with group statistics. Further, *Tau-U* handles
426 within phase level, and trend and variability within *and* between phases, as well as overlap
427 between phases. Therefore, reporting on visual inspection is limited to the immediacy of the
428 functional relation between *-ed* use and understanding, and the staggered introduction of
429 intervention across participants.

430 ***Pre-post analyses.*** Pre-post differences on standardised measures were tested in a
431 case series approach by calculating the Reliable Change Index (RCI) (Unicomb, Colyvas,
432 Harrison, & Hewat, 2015). The RCI statistic calculates whether an individual's change in
433 score (i.e. pre-post difference in standard scores) is statistically significant by using the
434 reliability values of a standardised test. The RCI is calculated using the formula $x_2 - x_1 / S_{diff}$,
435 where x_1 is the participant's pre-test score, x_2 is the same participant's post-test score, and S_{diff}

436 is the standard error of difference between the two test scores. An RCI above 1.96 is
437 considered statistically significant at 0.05 significance level.

438 **Results**

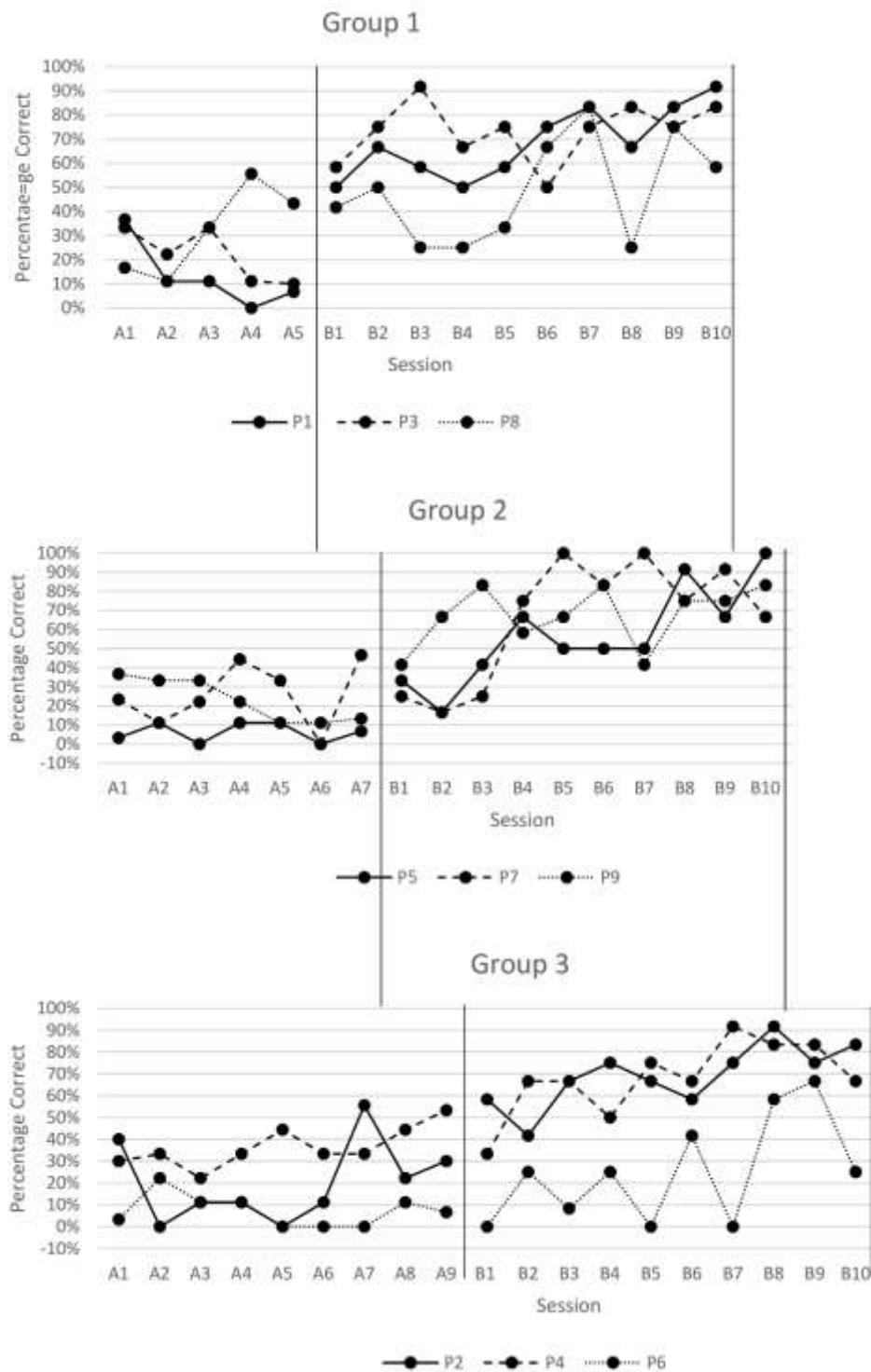
439 **Sequence completed**

440 All participants completed planned sessions within pre-intervention baseline (A),
441 intervention (B), and post-intervention maintenance (A) phases. There was an average of
442 50.74 (SD= 1.2; range 48-56) trials for each participant to produce *-ed*. Out of the nine
443 participants, six (P1, P2, P3, P4, P5, P7) demonstrated at or above 80% performance on at
444 least one measure of *-ed* marking over three sessions. These participants engaged in the ‘Silly
445 Sentences’ aspect of intervention procedures as described in the Intervention section.

446 **Outcomes and estimation**

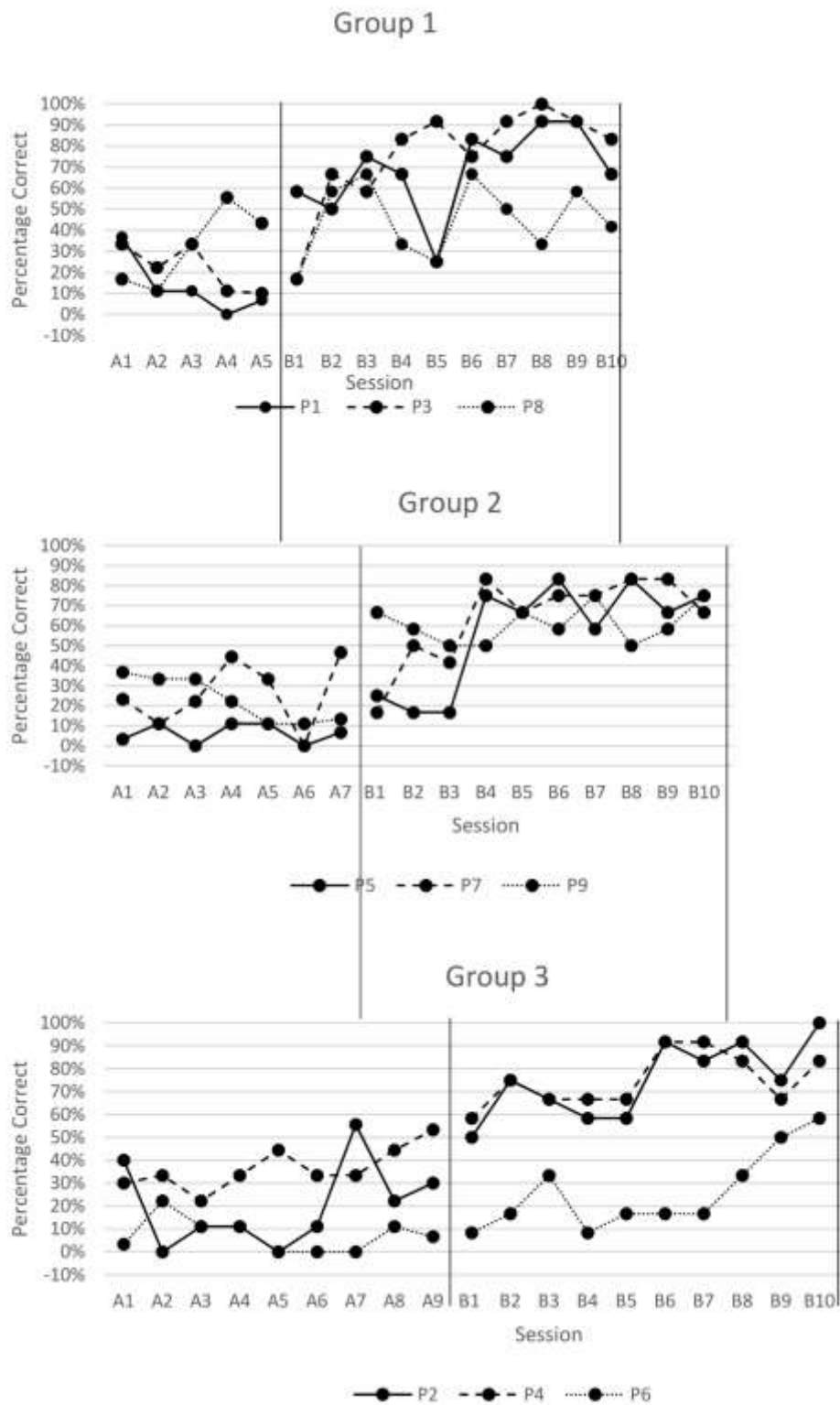
447 **Single subject treatment effects (expressive).** Data not reported in tables are
448 available in Supplementary Materials
449 ([https://asha.figshare.com/articles/Grammar_intervention_in_young_children_with_DLD_Ca](https://asha.figshare.com/articles/Grammar_intervention_in_young_children_with_DLD_Ca/11958771)
450 [lder et al 2020 /11958771](https://asha.figshare.com/articles/Grammar_intervention_in_young_children_with_DLD_Ca/11958771)). Pre-intervention baselines on production of *-ed* verbs taken
451 from the GET were stable for 4/9 participants. P1 ($Tau = -0.70$), P3 ($Tau = -0.70$), P4 ($Tau =$
452 0.58), P8 ($Tau = 0.60$) and P9 ($Tau = -0.71$) had baselines corrected for subsequent analyses.
453 Data from expressive repeated measures are presented in Figures 3-5 and results from $Tau-U$
454 analyses are reported in Table 2. Of the nine participants, eight (P1-P7, P9) demonstrated
455 statistically significant trend in production of trained verbs tested within-session during the
456 intervention phase (Figure 3). Phase contrasts were combined and yielded an aggregated
457 effect size of 0.88, which is considered large. For trained verbs tested between sessions
458 (Figure 4), seven (P1-P5, P7, P9) of the nine participants demonstrated statistically
459 significant performance during the intervention phase with a large aggregated effect size of

460 0.83. Seven (P1-P7) of the nine participants demonstrated a statistically significant trend in
 461 production of untrained *-ed* verbs during the intervention phase (Figure 5) yielding a medium
 462 effect size of 0.64.



463

464 *Figure 3.* Percentage correct on expressive trained within-session probe repeated measures for Groups 1-3.

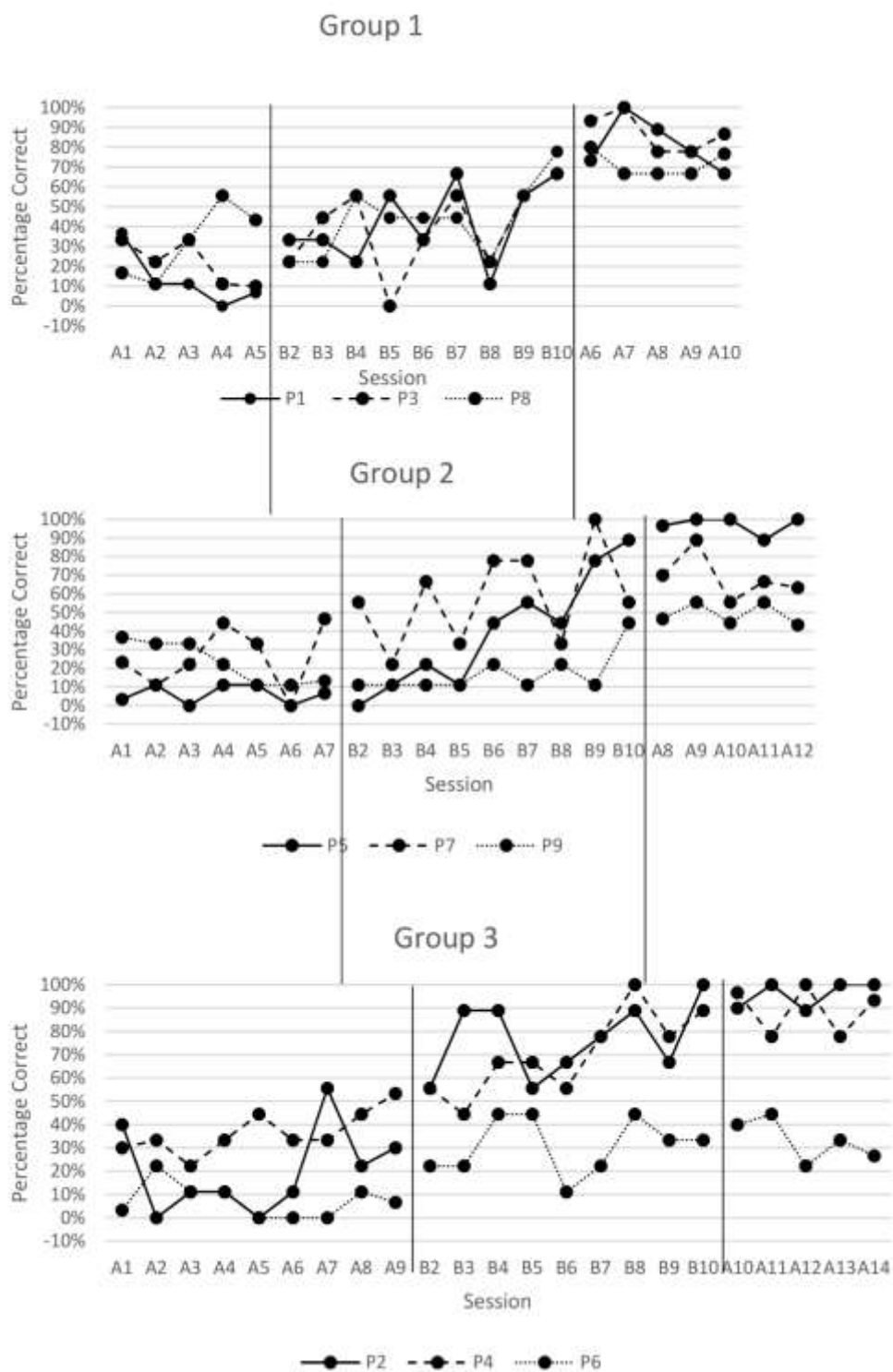


465

466 *Figure 4.* Percentage correct on expressive trained between-session probe repeated measures for Groups 1-3.

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470 *Figure 5.* Percentage correct on expressive untrained probe repeated measures for Groups 1-3.

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472 Table 2

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474 *Summary of expressive repeated measures baseline versus treatment phase contrasts on trained and untrained targets*

Participant ID	Kendall's S	z score	p value	Tau	90% CI
<u>WITHIN SESSION</u>					
P1 ^a	55	3.37	<0.001*	1.1	[0.56, 1]
P2	88	3.60	<0.001*	0.98	[0.53, 1]
P3 ^a	51	3.12	0.002*	1.02	[0.48, 1]
P4 ^a	69	2.82	0.005*	0.77	[0.32, 1]
P5	70	3.42	<0.001*	1	[0.52, 1]
P6	66	2.70	0.007*	0.73	[0.29, 1]
P7	56	2.73	0.006*	0.80	[0.32, 1]
P8 ^a	15	0.92	0.36	0.30	[0.24, 0.84]
P9 ^a	85	4.15	<0.001*	1.21	[0.73, 1]
				<u>Aggregated ES</u>	
Group	-	-	<0.001*	0.88	-
<u>BETWEEN SESSION</u>					
P1 ^a	57	3.49	<0.001*	1.14	[0.60, 1]
P2	88	3.59	<0.001*	0.98	[0.53, 1]
P3 ^a	57	3.49	<0.001*	1.14	[0.60, 1]
P4 ^a	57	2.33	0.02*	0.63	[0.19, 1]
P5	70	3.42	<0.001*	1.00	[0.52, 1]
P6	37	1.51	0.13	0.41	[-0.04, 0.86]
P7	48	2.34	0.02*	0.69	[0.20, 1]
P8 ^a	15	0.92	0.36	0.30	[-0.24, 0.84]
P9 ^a	85	4.13	<0.001*	1.21	[0.73, 1]
				<u>Aggregated ES</u>	
Group	-	-	<0.001*	0.83	-
<u>UNTRAINED</u>					
P1 ^a	40	2.67	0.007*	0.89	[0.34, 1]
P2	79	3.49	<0.001*	0.98	[0.52, 1]
P3 ^a	30	2.00	0.05*	0.67	[0.12, 1]

P4 ^a	56	2.47	0.01*	0.69	[0.23, 1]
P5	45	2.38	0.02*	0.71	[0.22, 1]
P6	73	3.22	0.001*	0.90	[0.44, 1]
P7	44	2.33	0.02*	0.70	[0.21, 1]
P8 ^a	13	0.87	0.39	0.29	[0.26, 0.84]
P9 ^a	-8	-0.42	0.67	-0.13	[0.62, 0.37]
				<u>Aggregated ES</u>	
Group	-	-	<0.001	0.64	-

475 *Notes.* CI= confidence interval; ES= effect size

476 *sig.

477 ^aunstable baseline corrected

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479

480 Analysis of *Tau* scores revealed a significant negative trend in performance for P1
481 (*Tau* = -0.40), P6 (*Tau* = -0.40) and P7 (*Tau* = -0.40) across five datapoints in the post-
482 intervention maintenance phase. Note the *Tau* values for these three participants is at
483 minimum level for baseline trend (*Tau* = ± 0.40) corrections according to Parker et al. (2011).

484 For expressive 3S extension probes, P7 (*Tau* = 0.62), P8 (*Tau* = 0.60) and P9 (*Tau* =
485 0.57) demonstrated an unstable baseline with a positive trend. During the intervention phase,
486 P6 demonstrated significant improvement ($p = .03$) and P9 demonstrated significant decline
487 ($p = .03$). Phase contrasts yielded a non-significant ($p = .65$) aggregated effect size of -0.05.
488 P1 (*Tau* = 0.80), P2 (*Tau* = 0.40) and P4 (*Tau* = 0.70) demonstrated positive trend in the post-
489 intervention maintenance phase.

490 For expressive 's control probes, P2 (*Tau* = 0.69) and P4 (*Tau* = 0.61) showed
491 unstable baselines with positive trends, while P9 (*Tau* = -0.43) showed an unstable baseline
492 with a negative trend. Of the nine participants, both P1 ($p = .013$) and P3 ($p = .004$)
493 demonstrated significant improvement during the intervention phase. Phase contrasts yielded
494 a non-significant ($p = .33$) aggregated effect size of 0.10. P5 (*Tau* = 0.40) continued to show
495 positive trend in the post-intervention maintenance phase, while P7 (*Tau* = -0.50), P8 (*Tau* = -
496 0.40) and P9 (*Tau* = -0.40) showed negative trend.

497 **Single subject treatment effects (grammaticality judgement).** Pre-intervention
498 baselines for past tense grammaticality judgement probes were stable for all participants.
499 Only one participant (P5) improved significantly in correctly judging grammaticality on
500 trained verbs tested within sessions ($p = 0.02$). P1 ($p = 0.04$) and P4 ($p = 0.04$) improved
501 significantly on trained verbs tested between sessions, and a small (0.26) yet significant
502 ($p = .009$) effect size across participants was calculated. Only one (P2) participant
503 demonstrated significant trend in correct grammaticality judgement of untrained *-ed* verbs

504 during the intervention phase ($p = .02$).

505 For grammaticality judgement 3S extension probes, P8 showed an unstable baseline
506 with negative trend, $Tau = -0.40$. P4 demonstrated significant improvement during
507 intervention ($p = .02$) and P8 demonstrated significant negative trend ($p = .02$). P2 ($Tau = -$
508 0.80). Phase contrasts yielded a small, yet significant ($p = .03$) aggregated effect size of 0.22 .
509 P8 ($Tau = -0.40$) demonstrated negative trend in the maintenance phase, while P3 ($Tau =$
510 0.53) demonstrated positive trend.

511 For grammaticality judgement 's control probes, P4 demonstrated negative trend,
512 while P7 ($Tau = 0.65$) and P8 ($Tau = 0.90$) demonstrated positive trend during baseline. P2
513 demonstrated significant positive trend during intervention ($p = 0.02$). Phase contrasts yielded
514 a non-significant ($p = .76$) aggregated effect size of 0.03 . P4 demonstrated negative trend in
515 the maintenance phase, $Tau = -0.40$.

516 **Within-group concurrent approach.** Mean scores and standard deviations for *-ed*
517 production and grammaticality judgement at four timepoints are presented in Table 3. A
518 Friedman two-way ANOVA demonstrated that production of untrained *-ed* verbs differed
519 significantly between timepoints, $\chi^2_F = 22.47$, $df = 3$, $p < .001$. Post-hoc Wilcoxon Signed
520 Rank tests and a Bonferroni adjusted α of 0.0167 ($0.05/3$ comparisons: Timepoint 1 vs
521 Timepoint 2; Timepoint 2 vs Timepoint 3, and; Timepoint 3 vs Timepoint 4) showed *-ed*
522 production was significantly higher at Timepoint 3 (Mean Rank= 3.78) than at Timepoint 2
523 (Mean Rank= 1.56), $z = -2.67$, $N\text{-Ties} = 9$, $p = .008$. Differences between other Timepoints
524 were non-significant, suggesting a stable pre-intervention baseline, an observable treatment
525 effect between pre- and post-intervention testing points, and maintenance of gains at a group
526 level. Tests for grammaticality judgement were non-significant.

527 Table 3

528

529 *Mean scores on complete sets of untrained past tense verbs across four time points*

Measure	Pre-intervention		Post-intervention	
	Timepoint 1	Timepoint 2	Timepoint 3	Timepoint 4
Expressive (/30)	7.44 (SD= 4)	7.44 (SD= 5.47) †	22.89 (SD= 5.97)*	21.89 (SD= 7.23) ††
Grammaticality judgement (/30)	15.22 (SD= 1.87)	16.22(SD= 1.03) †	19.25 (SD= 4.97)	18.78 (SD= 6.25)

530 *Notes.* SD= standard deviation.

531 †non-sig. difference between pre-intervention baseline timepoints= stable baseline.

532 *sig. difference between pre- and post-intervention timepoints= observed treatment effect.

533 ††non-sig. difference between post-intervention timepoints= maintained treatment effect.

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554 Table 4

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556 *Pre- and post-intervention standard scores*

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Participant ID	SPELT-3		TROG-2	
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
P1	69	76 (2.78)*	74	76 (0.24)
P2	90	111 (9.33)*	97	95 (0.24)
P3	79	102 (6.83)*	86	93 (0.83)
P4	71	105 (13.54)*	81	83 (0.24)
P5	57	90 (13.14)*	81	86 (0.35)
P6	72	78 (0.64)	65	58 (-0.83)
P7	84	100 (6.37)*	62	74 (1.42)
P8	69	88 (7.54)*	79	97 (2.12)*
P9	57	78 (8.33)*	65	67 (0.24)

558 *Notes.* Scores are standard scores with a mean of 100 and SD of 15. RCI= reliable change index; SPELT-3= Structured Photographic Expressive
 559 Language Test 3rd Edition; TROG-2= Test of Reception of Grammar 2nd Edition.

560 *statistically significant, i.e. above 1.96.

561

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564 **Analysis of pre-post results.** Pre- and post-intervention standard scores on the
565 SPELT-3 and TROG-2 are reported in Table 4. Exceeding the RCI of 1.96 indicates
566 statistically significant improvement. All but one participant (P6) exceeded the RCI for the
567 SPELT-3. Further, for the majority of participants, post-intervention standard scores
568 exceeded the manual-reported confidence intervals (90% and 95%) around their pre-
569 intervention standard scores. Note, however, that even though P1's RCI was significant, his
570 post-SPELT-3 standard score of 76 does not exceed the 90% and 95% confidence interval
571 around his pre-SPELT-3 standard score of 69. One participant (P8) exceeded the RCI for the
572 TROG-2 (2.12).

573 **Adverse events**

574 In the case of absence during the intervention phase, participants (P5, P6, P7, P8 and
575 P9) attended a make-up session in the final week of intervention in which within session and
576 between session teaching probes were collected. Due to issues with attention and
577 engagement, procedural changes occurred for P6, who received 30 trials per session, and the
578 systematic cueing hierarchy was limited to elicited imitation.

579 **Discussion**

580 This study evaluated the efficacy of an explicit grammar intervention combining
581 metalinguistic training and grammar facilitation aimed to improve regular past tense (*-ed*)
582 marking for nine children aged 5;10-6;8 years with DLD. Intervention taught *-ed* marking
583 through explicit rule instruction and visual supports using the SHAPE CODING™ system. A
584 systematic cuing hierarchy (Smith-Lock et al., 2015) was used to support participants. This
585 study contributes to the design, development and evaluation of intervention efficacy by
586 moving through levels of evidence and analogous research designs (Robey, 2004).

587 **Treatment effects**

588 **Single subject analyses.** We hypothesised participants would improve significantly
589 on *-ed* verbs trained and probed within sessions and between sessions. Most participants
590 improved on expressive repeated measures of trained verbs with large effects, indicating this
591 intervention is efficacious for improving production of *-ed* verbs taught in sessions. Further,
592 most participants improved on untrained verbs with medium effects, suggesting
593 generalisation. Within-group Friedman non-parametric two-way ANOVA also demonstrated
594 a generalised treatment effect, which was maintained for five weeks. For grammaticality
595 judgement, only three participants improved on trained verbs, one improved significantly on
596 untrained verbs, and another continued to improve five weeks post-intervention. Few gains
597 were observed across participants on an extension measure (3S) and on control measures of 's
598 both production and grammaticality judgement. Limited progress on control probes
599 strengthens our ability to attribute improvement on *-ed* production to intervention. Results
600 support the efficacy of intervention to improve *-ed* production on trained and untrained verbs;
601 however, we observed limited gains on grammaticality judgement measures.

602 Visual inspection of expressive repeated measures reflects results from statistical
603 analysis regarding the immediacy of the functional relation between *-ed* production and
604 intervention. That is, positive trend is observable upon the staggered introduction of
605 intervention across participants. Specifically, trained expressive probes appeared to improve
606 more rapidly, as early as week one of intervention, whereas for untrained verbs gains are
607 observable around the five-week mark across participants. Finally, visual inspection revealed
608 production of *-ed* on untrained verbs remained relatively stable for all children during the
609 post-intervention phase, supporting findings from within-group statistical analysis.

610 **Pre-post comparisons.** Pre-post comparisons of standard measures of expressive and
611 receptive grammar across participants mirrored single-subject analyses. Of the nine
612 participants, eight exceeded the RCI for expressive grammar and one child exceeded the RCI

613 for receptive grammar. Overall, pre-post analyses suggest the intervention had a broad effect
614 on expressive grammar captured through standardised grammar measures. However, effects
615 on measures of grammar comprehension were modest compared to expressive grammar.

616 **General discussion**

617 Results from the current study support and build upon findings in the literature.
618 Finestack (2018) demonstrated efficacy of explicit-implicit instruction using novel
619 morphemes, suggesting that the experimental approach may yield quicker gains, and
620 improvement closer to mastery compared to existing implicit-only intervention procedures.
621 Further, Finestack called for an evaluation of treatment effectiveness using true English
622 morphemes across measures of maintenance and generalisation to progress the clinical
623 applicability of research findings. Calder et al. (2018) piloted intervention with a small group
624 of early school-age children diagnosed with DLD. Findings suggested intervention
625 implemented over five weeks, twice per week without predefined dosage improved *-ed*
626 production of untrained verbs and standard measures of expressive and receptive grammar.
627 The authors concluded maintaining consistent dosage (i.e. 50 trials) and extending duration
628 (i.e. 10 weeks) may improve production on untrained verbs and discern optimal dose to allow
629 replication for clinical practice.

630 The current study applied recommended changes to intervention dose and intensity,
631 and predictions were supported. Further, using measures of verbs trained in session and those
632 from previous sessions allowed analysis of within- and between-session gains (e.g. Finestack,
633 2018). We saw that children showed greater and more rapid improvement on trained verbs
634 probed within and between sessions compared to untrained verbs. However, gains in standard
635 measures of receptive grammar were not observed to the extent reported in Calder et al.
636 (2018). It is likely that reduced improvement on the measure is attributable to the baseline

637 performance of the participants from the current study. That is, the baseline scores of the
638 current group of participants were higher than those reported in Calder et al., which may
639 suggest fewer gains were to be made on such a measure. This finding is consistent with
640 literature suggesting that receptive grammar is less amenable to improvement when
641 compared to expressive grammar (Ebbels, 2014).

642 From a theoretical perspective, limited improvement on receptive measures may be
643 due to the status of internal representations of language remaining relatively fixed. However,
644 increased production practice may establish new representations, such as those practised
645 within sessions, which are generalizable to similar targets, such as other verbs marked for *-ed*
646 or 3S. This pattern was observed with two participants (P2 and P4, respectively), so future
647 research is needed explore this claim further. Alternatively, the current standard measures of
648 receptive grammar may fall short of their aim. Recently, Frizelle et al. (2019) found multiple-
649 choice grammar tasks may underestimate children's abilities compared to truth-value tasks.
650 In the current study, probing grammaticality judgment of trained and untrained verbs allowed
651 investigation of improvement of obligatory tense marking as a specific behavior, although
652 improvement was limited across participants. This may provide evidence of the persistent
653 nature of language disorder (e.g. Dale et al., 2018). Alternatively, the task may be implicated
654 by other cognitive factors, such as phonological short-term memory. Regardless, further
655 research is needed to unpack effective methods to treat receptive language difficulties.

656 Current findings are comparable to recent studies targeting *-ed* marking in children
657 with DLD. For example, in a study using similar procedures to the current study, Smith-Lock
658 et al. (2015) demonstrated explicit rule instruction coupled with a systematic cueing
659 hierarchy was more effective in improving morphosyntax in preschool children with DLD
660 when compared to recasting alone. A key difference to intervention procedures reported in
661 this study is the inclusion of visual metalinguistic training and the *explicit* use of the cueing

662 hierarchy. That is, cues in this study were presented to highlight the targeted behaviour was
663 not observed, and so the children were encouraged to reflect on the rule they had just been
664 taught with the support of visuals and to self-correct. Further, the current study implemented
665 over double the cumulative intensity than Smith-Lock et al. (2015), although trials were not
666 specified in that study, so it is challenging to make direct comparisons. Finally, Van Horne et
667 al. (2017) reported positive treatment outcomes following intervention targeting *-ed*
668 production. Importantly, the primarily implicit intervention procedures outlined in Van Horne
669 et al. were effective in improving *-ed* for both studied groups following 36 sessions, which is
670 markedly longer than dose duration reported here and by Smith-Lock et al. (2015),
671 suggesting that explicit interventions may be more time efficient in improving expressive
672 grammar outcomes. Future research is needed to compare the superiority of the two
673 approaches to intervention.

674 This study further extends on a body of research evaluating the efficacy and
675 effectiveness of explicit interventions using visual support strategies to improve grammatical
676 knowledge for children with language difficulties, specifically, the SHAPE CODING™
677 system (Ebbels, 2007). Positive results of use of the system have been reported with older
678 children with DLD (Ebbels et al., 2007, 2014; Kulkarni et al., 2013), younger children with
679 DLD (Calder et al., 2018), and children with complex learning needs (Tobin & Ebbels,
680 2019). It should be noted that positive results were reported by Finestack (2018) where
681 metalinguistic training without visual support was efficacious in improving grammar in
682 young children with DLD. Continued research in this area will discern the extent to which the
683 visual aspect of the SHAPE CODING™ system is responsible for positive treatment effects.

684 We saw that children showed greater and more rapid improvement on verbs trained in
685 session when compared to untrained verbs, suggesting children with DLD may have
686 difficulty generalizing grammar skills, particularly those relying upon sequence learning,

687 such as finiteness marking. Therefore, we are more likely to see immediate improvement in
688 verbs trained via intervention compared to untrained verbs. We also expected there might
689 have been improvement on verbs marked for 3S, however this was not widespread across
690 participants, with P6 improving during intervention, and three (P1, P2, P4) improving post-
691 intervention. This finding suggests that, generally, grammar targets should be taught directly,
692 even if they are linguistically related to existing intervention targets for children with DLD.
693 Further, production practice did not seem to affect grammaticality judgment, however,
694 metalinguistic training may have. That is, regardless of practice trials being held consistent,
695 children for whom 'Silly Sentences' were introduced (P1, P2, P3, P4, P5, P7) appeared to
696 perform better on repeated measures of grammaticality judgment (see S10, S11, S12).
697 Therefore, introducing the sub-activity at the onset of treatment, rather than awaiting the 80%
698 accuracy criterion, may result in improvement of grammaticality judgment.

699 Other factors to consider when evaluating treatment effectiveness are environmental.
700 For example, the participant with the lowest performance in general (P6) had attended the
701 specialist school for the least amount of time, compared to P2 and P4, the strongest
702 performers who were in their third year at the specialist school. It could be that these children
703 were primed to learn during language-based tasks more so than P6. However, P6 also had the
704 lowest pre-intervention language scores and received fewer trials throughout the intervention
705 phase. Nonetheless, P6 still improved significantly despite these potential barriers. Through
706 SCEDs, evaluating individual treatment responses allows researchers and clinicians to
707 extricate factors related to responsiveness to intervention that may otherwise be lost in group
708 treatment studies (Plante, Tucci, Nicholas, Arizmendi, & Vance, 2018).

709 **Limitations**

710 There are limitations to this study. Firstly, generalizability of results using SCED
711 must be applied with caution. Although the methodology allows for analysis of treatment
712 effects for individuals, the lack of a control group and relatively small sample size inhibits the
713 ability to make causal inferences regarding treatment effectiveness in relation to the general
714 population. Further, within-participant analysis does not control for the influence of external
715 factors, such as classroom instruction, when compared to robust randomized group
716 comparison studies. Nonetheless, SCEDs provide a useful methodology for establishing an
717 early evidence-base for newly developed interventions (Fey & Finestack, 2008). In fact,
718 Horner et al. (2005) suggests results from a minimum of five studies totaling at least 20
719 participants across three different research teams are necessary to determine intervention
720 efficacy using high quality SCEDs prior to effectiveness being tested using clinical trials. The
721 current study was designed using guidelines developed by Kratochwill et al. (2012) and Tate
722 et al. (2016) to meet minimum standards for SCED to interpret treatment efficacy. Note that
723 an independent rater did not collect repeated measures within the baseline and intervention
724 phases as per Kratochwill et al.'s (2012) recommendation. However, strong inter-rater
725 reliability values addressed potential observer bias. Secondly, the current study used
726 convenience sampling to recruit participants from a specialized school designed to provide
727 intensive language and literacy support to young children with DLD. While non-verbal IQ
728 was not directly measured as part of this study, all participants were enrolled into an
729 educational program for children with DLD in the presence of average non-verbal IQ.
730 Further, socio-economic status of participants was unknown and the majority (8/9) of
731 participants were male. Therefore, the current sample may not be representative of the
732 population of children with DLD at large. Lastly, the current efficacy study was limited to the
733 analysis of *-ed* production and grammaticality judgment, and standard expressive and

734 receptive grammar scores. More naturalistic measures, such as narrative or conversation
735 sampling, may better serve as true measures of generalization in future studies.

736 **Clinical implications**

737 A recent survey of US speech pathologists investigating current clinical practices for
738 grammar intervention found that although a regular component of practice, specific aspects of
739 grammatical interventions are not well understood (Finestack & Satterlund, 2018). Further,
740 *-ed* marking is often targeted as a treatment goal, and explicit presentation is often used in
741 intervention procedures. However relatively little research has been reported using explicit
742 intervention for teaching *-ed* to early school-aged children. Fey and Finestack (2008)
743 proposed a framework for conceptualizing intervention components. The current intervention
744 is summarized in Table 5. This framework may serve as a point of reference for clinicians
745 planning to implement intervention to improve production of *-ed* for early school-aged
746 children with DLD. Clear intervention procedures and maintaining consistent dose
747 throughout the intervention phase also allows clinicians to replicate findings. It appears
748 generally that this intervention is less efficacious for improving grammaticality judgment of *-*
749 *ed*, with only a small intervention effect (0.26) observed. However, a similar effect (0.22)
750 was observed for grammaticality judgement of 3S, but not for the production or
751 grammaticality judgement of 's. Since 3S was not targeted directly but is linguistically
752 related, perhaps improvement for some children was due to the phonological saliency of /z, s/
753 compared to *-ed* /d, t/ providing a learning advantage to the morpheme when combined with
754 metalinguistic training.

Table 5

Framework for conceptualising intervention components proposed by Fey and Finestack (2008)

Intervention component	Experimental intervention
Children	5;10-6;8 year old children with DLD
Goals	Regular past tense (-ed) production and grammaticality judgment
Service delivery	1:1 with a speech-language pathologist in clinical contexts (within a specialized school)
Dosage	50 trials, 2x sessions per week for 10 weeks: 1000 trials over 20 sessions and ~7-10 hours of intervention
Procedures	Explicit intervention using metalinguistic training with visual support combined with an systematic cueing hierarchy
Activities	Naturalistic games with opportunities to produce -ed verbs (e.g. playdough, puppets, board games)
Measurement of outcomes	Standard grammar measures and criterion-referenced measures of -ed production and grammaticality judgment

1 **Conclusions**

2 Results continue to support the efficacy of explicit grammar interventions to improve
3 *-ed* marking in early school-aged children. Future research should continue to evaluate the
4 efficacy of similar interventions, for example, using more clinically relevant dosage (e.g. 1x
5 session per week). It is also important to determine whether explicit grammar interventions
6 can improve other aspects of grammatical difficulty for younger children with DLD, such as
7 copula/auxiliary use, or *wh-* questions. Overall, findings contribute to the understanding of
8 efficacious intervention procedures for early school-age children with DLD suggesting
9 children are able to apply knowledge acquired through explicit instruction.

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28 Appendix A

29 Checklist for scoring intervention procedure fidelity.

STEP	EXPLANATION	1/0
1. Explicit teaching	Remind child of the goal of the session	
1a. Activate prior knowledge		<input type="checkbox"/>
1b. Explain Goals		<input type="checkbox"/>
ACTIVITY 1		
2. Check vocabulary	Child asked to label materials from session linked to subject/object nouns Demonstrate 3x SV/O sentences using one exemplar from each of the allomorphic categories. Introduce 'left down arrow cues' each alongside its corresponding shape	<input type="checkbox"/>
3. Goal		<input type="checkbox"/>
4. Practice	25 trials to produce past tense <i>-ed</i> with systematic cueing Lay large shapes on the floor and student to use as cues to produce SV/O sentences	
4a. Coding		<input type="checkbox"/>
4b. Trials	22-28 trials achieved	<input type="checkbox"/>
4c. Cueing	Errors cued appropriately?	<input type="checkbox"/>
5. Consolidation	At the end of the session, review the 3x SV/O sentences using one exemplar from each of the allomorphic category.	
5a. Comprehension task	Student to produce SUBJECTs, VERBs, and OBJECTs following comprehension questions	<input type="checkbox"/>
5b. Production	Student says phrase	<input type="checkbox"/>
5c. Repeat without shapes	Student says phrase (cue as necessary)	<input type="checkbox"/>
ACTIVITY 2		
6. Check vocabulary	Child asked to label materials from session linked to subject/object nouns Demonstrate 3x SV/O sentences using one exemplar from each of the allomorphic categories. Introduce 'left down arrow cues' each alongside its corresponding shape	<input type="checkbox"/>
7. Goal		<input type="checkbox"/>
8. Practice	25 trials to produce past tense <i>-ed</i> with systematic cueing Lay large shapes on the floor and student to use as cues to produce SV/O sentences	
8a. Coding		<input type="checkbox"/>
8b. Trials	22-28 trials achieved	<input type="checkbox"/>
8c. Cueing	Errors cued appropriately?	<input type="checkbox"/>
9. Consolidation	At the end of the session, review the 3x SV/O sentences using one exemplar from each of the allomorphic category.	
9a. Comprehension task	Student to produce SUBJECTs, VERBs, and OBJECTs following comprehension questions	<input type="checkbox"/>
9b. Production	Student says phrase	<input type="checkbox"/>
9c. Repeat without shapes	Student says phrase (cue as necessary)	<input type="checkbox"/>
10. Summarise	Remind child of the goal of the session	<input type="checkbox"/>
TOTAL:		/19
PERCENTAGE ACCURACY:		%

Appendix B

List of Supplemental Materials

- S1: Expressive raw scores of participants on trained past tense verbs within-session.
- S2: Expressive raw scores of participants on trained past tense verbs between-session.
- S3: Expressive raw scores of participants on untrained past tense verbs.
- S4: Expressive scores of participants on third person singular (extension).
- S5: Summary of Tau-U analyses for expressive repeated measures baseline versus treatment phase contrasts on untrained third person singular targets (extension).
- S6: Graph of % correct on expressive third person singular repeated measures (extension).
- S7: Expressive raw scores of participants on possessive 's (control).
- S8: Summary of expressive repeated measures baseline versus treatment phase contrasts on untrained possessive 's targets (control).
- S9: Graph of % correct on expressive possessive 's repeated measures (control).
- S10: Grammaticality judgment raw scores of participants on trained past tense verbs within-session.
- S11: Grammaticality judgment raw scores of participants on trained past tense verbs between-session.
- S12: Grammaticality judgment raw scores of participants on untrained past tense verbs.
- S13: Summary of grammaticality judgment repeated measures baseline versus treatment phase contrasts on trained and untrained targets.
- S14: Graph of % correct on grammaticality judgment within-session repeated measures.
- S15: Graph of % correct on grammaticality judgment between-session repeated measures.

S16: Graph of % correct on expressive untrained repeated measures.

S17: Grammaticality judgment raw scores of participants on third person singular (extension).

S18: Summary grammaticality judgment repeated measures baseline versus treatment phase contrasts on untrained third person singular targets (extension).

S19: Graph of % correct on grammaticality judgment third person singular repeated measures (extension).

S20: Grammaticality judgment raw scores of participants on possessive 's (control).

S21: Summary of grammaticality judgment repeated measures baseline versus treatment phase contrasts on untrained possessive 's targets (control).

S22: Graph of % correct on grammaticality judgment possessive 's repeated measures (control).