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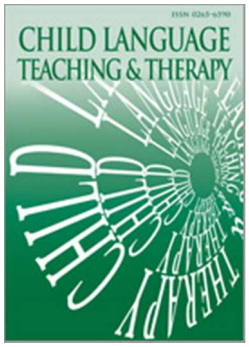

Phonological or morphological intervention? Evidence from a Greek-speaking child with persisting speech difficulties

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Abstract:	Intervention with children with speech and language difficulties has been proven beneficial compared with no treatment yet, knowing what type of intervention to provide remains a challenge. Studies of English-speaking children indicate that intervention targeting the production of morphological targets may have a positive effect on phonological aspects and vice versa. However, studies have not reported on generalization effects to untreated morphemes and little is yet known about morphological intervention in the context of a highly inflected language. The purpose of the current intervention case study was to investigate the effect of intervention in relation to phonological and morphological targets in Greek, a language characterized by complex inflectional morphology. A single subject research design was used with pre- and post-intervention assessment carried out. The participant was a four-year-old Greek-speaking boy with speech difficulties. The production of /s/, a phoneme used in multiple phonological and morphological contexts was targeted with alternating focus of intervention between phonological and morphological targets. Assessment took place at two levels: macro-assessment to monitor broad changes in speech; micro-assessment to measure therapy-specific changes in the production of treated targets and generalization to untreated targets and control items. There were four phases of intervention with a total of 24 hours of therapy. Significant improvement in performance accuracy was found between assessment scores immediately pre- and post-intervention. Intervention targeting the production of a phoneme in the word stem was not sufficient to accomplish the accurate production of morphemes requiring the same phoneme; intervention directly targeting morphemes was successful. Within-domain generalization was observed in both domains. Improved naming accuracy was observed post-intervention that was maintained at follow-up.

	The same speech processing intervention principles as are followed for the achievement of phonological objectives may be necessary for the accurate production of morphemes for children with speech difficulties.

Introduction

Interactions between the levels of the language system may influence the linguistic performance of a person with communication difficulties (Crystal, 1987). Speech and language difficulties frequently co-occur (Broomfield and Dodd, 2004; Shriberg, Tomblin and McSweeny, 1999). The question of whether morphological errors of children with speech sound disorders reflect their phonological weaknesses has been raised (Haskill & Tyler, 2007; Rvachew, Gaines, Cloutier, & Blanchet, 2005; Seeff-Gabriel, Chiat, & Pring, 2012). An answer to this question would have important implications with regard to whether it is necessary to target the two domains separately or whether a more efficient, less time consuming approach can be adopted in the expectation that intervention for one domain (phonology) will generalize to the other (morphology).

The connection between errors in speech production and expressive morphology has been explored in English-speaking children attending speech therapy (Rvachew et al., 2005). Production accuracy of /s/, /z/ with morphological function (plural, possessive, third person singular) was lower compared with the production of these phonemes in uninflected words, suggesting that speech difficulties could not fully account for difficulties with morphology.

The association between morphological errors and underpinning phonological errors was investigated by Haskill and Tyler (2007) in subgroups of children with language impairment and varying degrees of speech difficulties. Morpheme production performance of participants facing difficulties solely with language was similar to typically developing controls; co-morbid difficulties had a cumulative effect on morphological production. A discrepancy in production of phonologically similar yet

grammatically different forms suggests that the ability to produce specific phonemes may not be sufficient for the accurate production of morphophonemes.

A number of group studies (Tyler et al. 2002; 2003) of children with co-occurring speech and language difficulties investigate the direct effects of intervention on a treated domain, and indirect effects on areas other than the one targeted. Preschool age children with impairments in both domains were randomly assigned either to intervention starting with phonology followed by morphology, or the reverse (Tyler et al., 2002). Results indicated that both treatment groups made statistically significant progress in the treated domain as compared to controls who did not receive any intervention. Overall morphosyntactic performance was slightly better when morphosyntax was targeted prior to phonology, suggesting that children's speech does not have to be fully intelligible for morphological intervention to commence.

Tyler et al. (2003) further compared the outcomes of different strategies with intervention targeting: (a) phonology followed by morphology, (b) morphology followed by phonology, (c) alternating phonological – morphological targets weekly, (d) simultaneously targeting phonology and morphology. No single strategy was superior in improving phonology post-intervention. The alternating strategy was associated with greatest gains in morphosyntax. The authors draw attention to high variability in intervention outcome for individual participants in the same group, suggesting that one type of intervention may not have been equally beneficial for all. Differences in starting level and type of errors among participants led to variation in intervention outcome. Therefore, individual analysis would be revealing about treatment efficacy for particular profiles of difficulty. Such an analysis is more feasible within the context of a single case

study, to elucidate individual differences and allow for an in depth evaluation of treatment efficacy (Pascoe, Stackhouse and Wells, 2005).

A first single case study in the area of morphological and phonological change following intervention was conducted by Seeff-Gabriel, Chiat and Pring (2012). Their participant, an English-speaking child aged 5 years old and referred to as B, had difficulty with the production of regular past tense, although he was able to produce /t/, /d/ in word final position, suggesting that his difficulty could be morphosyntactic. He had difficulty with the production of plural nouns and was unable to produce /s/, /z/ at all in final position, suggesting a difficulty with alveolar fricatives at the phonological or articulatory level. Intervention initially targeted the production of regular past tense; upon intervention most errors were observed in verbs requiring the past tense ending /ɪd/, indicating that past tense marking was influenced by phonological factors. Intervention then targeted the production of final /s/ as a phonological precondition for the accurate production of regular plural nouns. Upon intervention B was able to produce word final /s/ accurately, but word initial and medial targets did not improve. Although B consistently used a word final consonant to mark plural, phonologically accurate production was limited. A third phase of intervention directly targeted /z/ in word final position. Upon intervention B was able to produce /z/ accurately in monomorphemic targets; he realized final /z/ as a plosive when it was required for plural marking, indicative of an interaction between speech and morphosyntax. This study demonstrates how single case studies can reveal in detail the reciprocal relationships between phonology and morphology.

Pascoe et al. (2005) put emphasis on theoretical basis on intervention studies, presenting the case of Katy a 6;5 years child with persisting speech difficulties. In order to inform intervention at single word and connected speech levels, the speech processing model and profile as described by Stackhouse and Wells (1997) were used. The speech processing model distinguishes between distinct levels of input processing (skills involved in decoding speech), output processing (skills involved in encoding and production of speech) and lexical representations i.e. stored knowledge about a word's form (phonological representation), meaning (semantic representation) and specific articulatory gestures required for production (motor program). The speech processing profile, a series of questions tapping into different components of speech processing can reveal individual strengths and weaknesses. A theory based approach allows clinicians to deliver principled intervention and to be explicit in interpretation of the intervention outcome. The psycholinguistic approach has been successful in profiling Greek children with speech sound disorders (Geronikou and Rees, 2016).

In summary, researchers have attempted to investigate to what extent difficulties with expressive morphology may be attributed to speech production errors (Rvachew et al., 2005; Haskill and Tyler, 2007) and the impact that therapy on one domain may have on another (Seeff-Gabriel et al., 2012; Tyler et al., 2002; 2003). Data from children with speech difficulties point to an interaction between phonology and other linguistic levels, although the nature of this interaction is not yet clear. Provision of intervention for children with primary speech and/or language difficulties has proven beneficial compared with no treatment (Broomfield and Dodd, 2011). Provision of the most effective intervention for each case remains a challenge. Intervention on morphological targets

when the level of phonological skills development is insufficient for the proper realization of morphophonemes has not been studied in highly inflected languages.

The purpose of the current intervention case study was to investigate the effect of intervention for phonological and morphological targets in Greek. Notable features of the Greek language are its complex inflectional system (Holton, Mackridge, & Philippaki-Warburton, 1997) and the use of polysyllabic stems (Aidinis and Nunes, 2001). Greek children have to process polysyllabic stems for commonly used words as [kɐɾɐˈmɛl-ɐ] (candy) in combination with the appropriate morpheme for case and number. The study in the context of complex morphology could elucidate aspects of the organization of lexical representation, including grammatical representations, which may not be feasible to study in morphologically simpler languages. Longitudinal investigation in typically developing Greek-speaking children provides evidence that comparable speech processing skills underpin the development of phonology and morphology (Geronikou, 2016).

A single case study design was chosen to allow detailed analysis of performance during phases of intervention and to promote insight into the organization of stored linguistic knowledge and its articulation in a particular child.

On account of the findings of morphophonological intervention in English-speaking children (Tyler et al., 2002; 2003) and speech processing development in Greek-speaking children (Geronikou, 2016) the following broad questions are addressed with regard to intervention for a child with phonological and morphological difficulties :

a. If intervention in the phonological domain results in change, will the change be restricted to the phonological domain or will generalization occur to the untreated morphological domain?

b. If intervention in the morphological domain results in change, will the change be restricted to the morphological domain or will generalization occur to the untreated phonological domain?

c. Will there be positive effects on speech production accuracy as a result of specific intervention targeting either phonological or morphological domains?

Methods and Procedures

Participant

Harry was 4;2 years old at the time of first assessment, and was attending nursery in a public school setting in Patras, Greece. There was no history of medical problems. He had achieved developmental milestones as expected. He had normal hearing and vision; he spoke Greek as his first language. He had just been referred to speech and language therapy.

To be considered for intervention delivery within the context of the present intervention study, the age of 4;0 years old was set as a criterion, since in typical development the production of the phoneme /s/ has been acquired at this age and the phonological process of final consonant deletion in closed syllables is eliminated when the syllable is at the end of the word (Papathanasiou et al., 2012). A second selection criterion for speech difficulties was set, namely indicated by ≤ -1.5 S.D. from age matched controls performance on Percentage Consonants Correct (PCC) in a naming

task. Harry scored 61.4% PCC compared to 89.84% (12.07 S.D.) of typically developing controls aged 4;0-4;6 years (Geronikou, 2016). The criterion of -1.5 S.D. below the mean performance of typically developing children has been frequently used (Law et al., 2000) in identifying children needing intervention. Harry could not produce the target phoneme accurately in CV structure and consonant clusters; /s/ and /z/ were constantly substituted by laterals [ɬ] and [ɮ] respectively, irrespective of phonotactic context and morphological status. He also substituted /ɾ/ by [l].

Design

In order to investigate the broad research questions stated above, Harry's production of /s/ was targeted in different intervention phases with the focus of intervention alternating between phonological and morphological components.

The following specific research questions are addressed:

1. Once /s/ is realized accurately by the child in a particular phonotactic structure is there generalization to the production of the same phoneme in other structures?

2. Once /s/ is realized accurately by the child in a particular morpheme is there generalization to the production of other morphemes that also require the production of /s/?

3. What is the effect of phonologically oriented intervention for /s/ on production of grammatical morphemes that require the production of this phoneme?

4. What is the effect of morphologically oriented intervention on the production of /s/ as part of the phonological system?

5. Is there a change in the child's speech production accuracy as a result of this intervention?

A single subject research design was used. Baseline assessment was carried out twice: two months pre-intervention and immediately pre-intervention. Four phases of intervention, focusing on phonological characteristics of targets (at odd-numbered intervention phases) and morphological characteristics of targets (at the even-numbered intervention phases) were conducted. Post-intervention assessment was carried out twice: immediately post-intervention and two months post-intervention.

Macro assessment:

A detailed assessment battery (Geronikou, 2016) was used pre- and post-intervention to monitor broad changes in speech input and output processing and language comprehension and production abilities. Given the second selection criterion, PCC performance accuracy will be presented here. This measurement is based on data from the Greek adaptation of Renfrew Word Finding test (Vogindroukas, Protopapas and Sideridis, 2009). Black and white line drawings were presented for the child to produce a spoken response. No data is presented from the other aspects of the assessment battery.

Micro assessment:

In order to measure therapy-specific changes a number of stimuli (Appendix 1) were used to collect repeated measures of probe assessment pre- and post-intervention and upon completion of each intervention phase. In the latter case, they were carried out at the beginning of the next session.

The research design is illustrated in Figure 1.

Insert Figure 1

Intervention Phases

In Greek, the target phoneme /s/ is used in multiple phonological contexts in the word stem in $C_{(0-3)}$-V-$C_{(0-1)}$ structures, in syllable initial (SI), word initial (WI) and word within

(WW) position. Consonant clusters such as /sk, st, sp/ are never used in syllable final (SF) position (Mennen and Okalidou, 2006). It is also used in a variety of morphological contexts to indicate the grammatical status of words such as gender, case and tense (Holton, Mackridge and Philippaki-Warburton, 1997). Relevant examples will be given in the following section. The corresponding voiced phoneme /z/ is used in SIWI and SIWW position in the word stem and as a morpheme for continuous tenses but it is not related to noun morphology.

Phase 1

The production of /s/ for phonological purposes was targeted in the word stem, in CV structure at SIWI position as ['sinɛfo] (cloud) and SIWW position as [ni'si] (island). There were 20 SIWI and 20 SIWW treated items. Six intervention sessions were designed.

Phase 2

The production of /s/ for morphological purposes was targeted in the word suffix, in SFWF position for the manifestation of a) genitive case for feminine nouns in singular (GFS) as [mɐ'mɐs] (mum's) and b) accusative case for masculine nouns in plural (AMP) as ['ɐdɾɛs] (men). Stress can be on any of the last three syllables (Arvaniti, 2007); the inflected form (compared to the nominative case) does not involve change of stress position but requires the presence of /s/ as a suffix. There were 20 GFS and 20 AMP treated items. Six intervention sessions were designed.

Phase 3

The production of /s/ in the consonant clusters /sk/ and /ks/ for phonological purposes was targeted in the word stem; in WI as ['ksilo] (wood) and WW position as ['tokso] (bow). There were 15 /sk/ WI and 10 /sk/ WW treated items, 10 /ks/ WI and 10 /ks/ WW treated items. Seven intervention sessions were designed.

Phase 4:

The production of /ks/ for morphological purposes was targeted as a suffix of simple past tense, in the final syllable as [ˈfonɐksɛ] (shouted). There were 12 treated items for /ks/ used as a past tense morpheme. Five intervention sessions were designed.

Procedure and Materials:

Probe assessment

A picture-naming task was used in repeated probes to assess:

Therapy-targeted treated items

For each of the intervention goals, three of the treated items were selected, for example [ˈskɐlɐ] (ladder) a treated item for the target /sk/ in SIWI position. Treated stimuli (Appendix 1, first column) were used to evaluate intervention outcome on items directly targeted.

Therapy-targeted untreated items

For each of the intervention goals, three items with phonological or morphological properties identical to the treated items were selected; for example, [ˈskavi] (digs) for the target /sk/ in SIWI position. These items that carefully remained untreated during intervention (Appendix 1, second column) were used to evaluate across-item generalization.

Not targeted in therapy – control items

For each of the intervention goals, three items with phonological or morphological properties similar, yet somewhat different from the targets were selected; for example words with cluster /st/, not targeted in intervention were matched to the targeted cluster /sk/. Control items (Appendix 1, third column) were used to observe any possible within domain generalization.

Not targeted in therapy, more distinctive items:

For each intervention goal, items sufficiently different from those included in intervention, yet within domains of phonology or morphology were selected for example, corresponding to /s/ clusters /ɾ/ clusters. Distinctive stimuli (Appendix 1, fourth column) were used to evaluate broad-spectrum development of skills. If the child succeeded on treated and untreated items, but not on these more distinctive items it would suggest that change observed could be attributed to intervention. Comparison of performance during periods of no intervention delivery would suggest if any noticeable change could be attributed to maturation.

Regardless of the phase where each target was introduced, the same stimuli were used as micro-evaluation in all probe assessments.

Intervention delivery

A four-phase intervention plan with predefined activities for the production of /s/ in phonological and morphological contexts was designed. Harry received speech therapy sessions for 45 minutes twice a week for three months (24 sessions) by the first author.

Principles of traditional articulation therapy (Van Riper and Emerick, 1984) were adopted, targets being graded from simpler to more complex structures. With regard to phonological elements, accurate production of /s/ was targeted in the word stem in CV phonotactic structures in Phase 1 and in CCV structures in Phase 3. With regard to morphological elements, accurate production of /s/ was targeted in CVC phonotactic structures in the word ending in Phase 2 and CCV structures in Phase 4. Accurate production was progressively targeted at syllabic, word and sentence level.

The other set of guiding principles that informed intervention planning was provided by psycholinguistic theory. Care was taken to include activities addressing potential difficulties at various levels of input and output processing that might hinder the

realization of /s/ in spontaneous speech. From a psycholinguistic perspective the difference between imitation and spontaneous production of phonological targets (Appendix 2, activity 1) and morphemes in context (Appendix 2, activity 3) is interpreted in terms of different requirements for access to stored representations.

In accordance with the psycholinguistic approach, the focus of intervention was also on the input processing of phonological and morphological components. Tasks tapping auditory discrimination (Appendix 2, activity 2) were used. Materials commonly used with children of this age were used. Activities included colorful pictures, for him to name and pairs of pictures, phonologically or morphologically similar, for him to identify which he had heard.

Harry followed the therapeutic activities at his own pace, for as many times as needed to reach 80% criterion of success in a particular activity.

Results

Performance during intervention phases

Harry's performance on repeated probe assessments across intervention phases can be seen in Table 1. Inspection of the first column in shaded boxes indicates whether change is observed once a specific target has been introduced in intervention (research questions 1 & 2). The last column in shaded boxes indicates whether intervention outcome is preserved at follow-up. Inspection of performance down the rows, outside the shaded boxes, indicates whether there is an effect of targeting something in one phase on other items that have not yet been targeted in intervention (research questions 3 & 4).

Insert Table 1

Probe assessment revealed that performance was stable in baseline assessment for a period of two months before the initiation of intervention. Production of the target phoneme was inaccurate in CV structure and in consonant clusters.

Once a target was introduced in intervention performance improved, for example accurate productions of /s/ in CV structure were observed upon completion of Phase 1. There was some generalization to targets that had not yet been introduced in intervention for example accurate productions of /sk/ and inaccurate production of /st/ upon completion of Phase 1, when clusters had not been targeted. Within domain generalization to untreated items was observed both for phonological (upon completion of Phase 1) and morphological targets (upon completion of Phase 2). Across domain generalization was not observed.

Two months post completion of intervention delivery Harry retained the ability to produce accurately /s/ in SIWI and SIWW position, in CV and CCV structures both for treated and untreated items. He did not produce accurately /s/ in SFWF position, when required for the manifestation of morphemes. He produced /ks/ as a morpheme of simple past.

Comparison of pre- and post-intervention performance

To investigate the effectiveness of intervention pre- and post-intervention performance accuracy on micro-assessment (Figure 2) and macro-assessment (Figure 3) were compared.

Insert Figure 2

A Cochran's Q test indicated a statistically significant difference between scores for treated ($x^2(3) = 54.33$, $p < .001$), untreated ($x^2(3) = 56.86$, $p < .001$) and control items

($x^2(3) = 19.85$, $p < .001$) at the four points of assessment. Pairwise comparison of performance accuracy was performed using two-tailed McNemar tests with Bonferroni correction for multiple comparisons. A value of $p > .008$ indicates a difference that would not maintain significance under Bonferroni correction.

Performance accuracy on probe assessment post-intervention was significantly better than performance pre-intervention for treated ($p < .001$) and untreated items ($p < .001$). Two months post-intervention Harry scored significantly lower than immediately post-intervention for untreated items ($p = .001$) indicating that the effect of intervention was not maintained fully. Some effect of intervention was maintained since his score two months post-intervention remained significantly higher than his score pre-intervention for treated ($p < .001$) and untreated items ($p < .001$).

A significant difference was found between performance accuracy for control items immediately pre-intervention and immediately post-intervention ($p = .008$); no significant difference was found between performance pre-intervention and two months post-intervention ($p = .500$), so there was no lasting effect of intervention on control items.

Insert Figure 3

A Cochran's Q test indicated a statistically significant difference between PCC scores at the four points of assessment ($x^2(3) = 65.02$, $p < .001$). Pairwise comparison was performed using two-tailed McNemar tests. A statistically significant difference was found between performance accuracy immediately pre-intervention and immediately-post intervention ($p < .001$). Increase in PCC accuracy was maintained two months post-intervention.

Discussion

The main issues driving this intervention case study concern whether any effects of treatment are limited to the domain that has been targeted. A further interest is whether such specifically targeted interventions lead to a broader change in speech production. These issues were operationalised in term of five specific research questions, which will now be considered in the light of Harry's performance.

Generalization of /s/ from one phonotactic structure to other structures within the phonological domain

When therapy follows a phonological direction some generalization of /s/ to other lexical items and other phonotactic structures was observed, for example accurate production of clusters once CV structure was targeted. Across item generalization has been commonly reported as an intervention outcome in the literature of speech sound disorders (Pascoe et al., 2005; Seeff-Gabriel et al., 2012). Generalization of the target phoneme was partial indicating that Harry did not store /s/ as a single member of the sound system that can be used in different phonotactic positions.

Generalization of a morphological target to other morphological targets

When therapy follows a morphological direction, Harry was able to generalize to the appropriate production of untreated morphological targets and not targeted controls that require /s/ in WF position. This finding allows the hypothesis that morphological characteristics are an integral part of lexical representations. Within the speech processing model proposed by Stackhouse and Wells (1997), updating stored motor programs of words with the intention that morphemes can be accurately generated could be expected to stimulate motor programming skills, leading to some revision or updating

of the child's current stored representations. Phonological representations and motor programs may need to be specified as to the different morphemes that can be attached in semantic representations (word stem). Existing studies with English-speaking children have not yet reported on a morphological intervention outcome with other untreated morphemes.

The effect of phonologically oriented intervention on production of grammatical morphemes

The next question to be considered is whether therapy aiming at the production of the phoneme /s/ in phonological contexts will facilitate the production of morphemes that require the accurate production of that phoneme. In the case of Harry no such generalization occurred. This was particularly evident upon completion of Phase 3. Harry was able to produce target /ks/ accurately as [ks] in SIWW position, when included in the word stem but he maintained substitution by [kł] in morpheme production of simple past tense, which entail the same cluster in the same word position. As a result of intervention targeting the phonological details of morphological suffixes Vance (1997) reports the development of some awareness and use of these endings, that was not systematic in spontaneous speech. In the present study the development of phonological competence was not sufficient to trigger the production of accurate morphemes. Intervention directly targeting the accurate production of morphemes was required.

The effect of morphologically oriented intervention on the production of phonemes

Regarding gains in the phonological domain, when intervention targets the production of morphemes generalization to phonological targets was not observed. Group

studies for English-speaking children (Tyler et al., 2002) indicate that addressing the morphosyntactic level leads to improvements at the phonological level.

Change in speech production accuracy as a result of intervention

There were beneficial effects of the intervention program to speech production abilities; Harry's performance post-intervention reveals more than 10% increase in PCC accuracy rate in spontaneous naming, similar to findings of intervention studies with English-speaking children, such as those of McNeill, Gillon and Dodd (2009) and Tyler et al. (2003). It seems that Harry developed lower level execution skills that enabled him to produce phoneme /s/ in a wide range of positions and phonotactic structures and he also created more accurate motor programs.

Comments on intervention outcome

Two months post-intervention, maintenance of correct production of phonological targets was better preserved compared with morphological ones. The production of /s/ in the WF position was not preserved at all. An explanation could be that phonemes found at the word end are more vulnerable, due to the co-articulation with phonemes which follow. Another explanation could be that since the phoneme /s/ in WF position is not required in each case of a noun, the frequency of its use is lower than in instances where the phoneme is in the word stem and thus obligatory in every context. This is supported by the fact that accurate production of /ks/ in WW position is higher when included in the word stem than when it is required as a past tense suffix.

Conclusions

The current study is the first study reporting controlled intervention with a Greek-speaking child who did not have the necessary speech processing skills for the accurate production of a phoneme that is used in morphological context.

Targeting the accurate production of morphemes enabled him to specify the phoneme at the level of lexical representations. Development was extended to speech production skills.

Cross-domain generalization from phonology to morphology was limited. This has some clinical implications, indicating that in a comprehensive intervention the production of morphemes may need to be targeted, even in the absence of accompanying language difficulties, in the case that speech errors are involved in morpheme production.

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	2 months pre-Intervention	Pre-Intervention	Phase 1	Phase 2	Phase 3	Phase 4	2 months post-Intervention
Phase 1: Phonological /s/ in word stem							
Targets treated /s/	0/6	0/6	4/6	0/6	3/6	5/6	4/6
Targets untreated /s/	0/6	0/6	1/6	0/6	5/6	4/6	3/6
Not targeted controls /z/	0/6	0/6	0/6	0/6	0/6	0/6	0/6
Phase 2: Morphological /s/ in word suffix Genitive Feminine Singular (GFS) , Accusative Masculine Plural (AMP)							
Targets treated /s/ GFS, AMP	0/6	0/6	0/6	6/6	4/6	5/6	0/6
Targets untreated /s/ GFS, AMP	0/6	0/6	0/6	6/6	6/6	6/6	0/6
Not targeted controls /s/Accusative Feminine Plural	0/6	0/6	0/6	6/6	6/6	6/6	0/6
Distinctive controls /n/ Genitive Plural	6/6	6/6	6/6	6/6	6/6	6/6	6/6
Phase 3: Phonological /s/clusters in word stem							
Targets treated /sk/	0/6	0/6	3/6	1/6	5/6	5/6	6/6
Targets untreated /sk/	0/6	0/6	1/6	1/6	1/6	6/6	6/6
Not targeted controls /st/	0/6	0/6	0/6	0/6	3/6	2/6	2/6
Targets treated /ks/	0/6	0/6	0/6	0/6	3/6	4/6	4/6
Targets untreated /ks/	0/6	0/6	0/6	0/6	1/6	5/6	3/6
Not targeted controls /ps/	0/6	0/6	0/6	0/6	0/6	0/6	0/6
Distinctive controls /tr/	0/6	1/6	3/6	3/6	3/6	4/6	4/6
Phase 4: Morphological /ks/ simple past suffix							
Targets treated /ks/ past	0/3	0/3	0/3	0/3	0/3	3/3	1/3
Targets untreated /ks/ past	0/3	0/3	0/3	0/3	0/3	2/3	1/3
Not targeted controls /ps/ past	0/3	0/3	0/3	0/3	0/3	0/3	0/3
Distinctive controls passive voice	1/3	1/3	3/3	2/3	2/3	3/3	3/3
Performance on items that have been targeted in intervention is enclosed in shaded boxes							

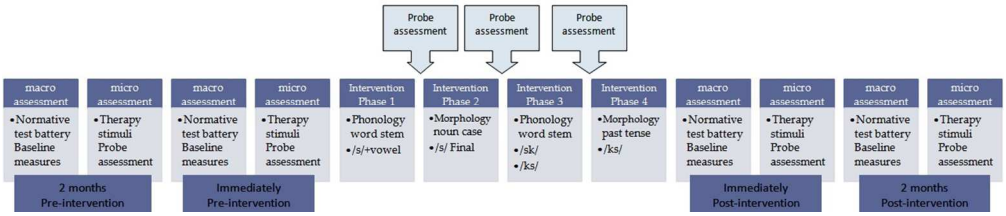

Figure 1 Research design

338x71mm (96 x 96 DPI)

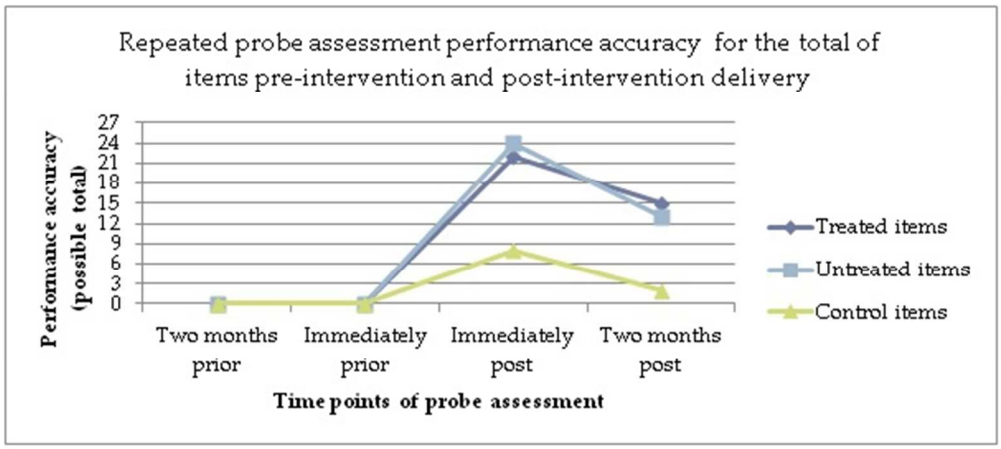

Figure 2 Comparison of Harry's performance in probe assessment for the total of treated, untreated and control items at baseline pre-intervention and post-intervention delivery

160x71mm (96 x 96 DPI)

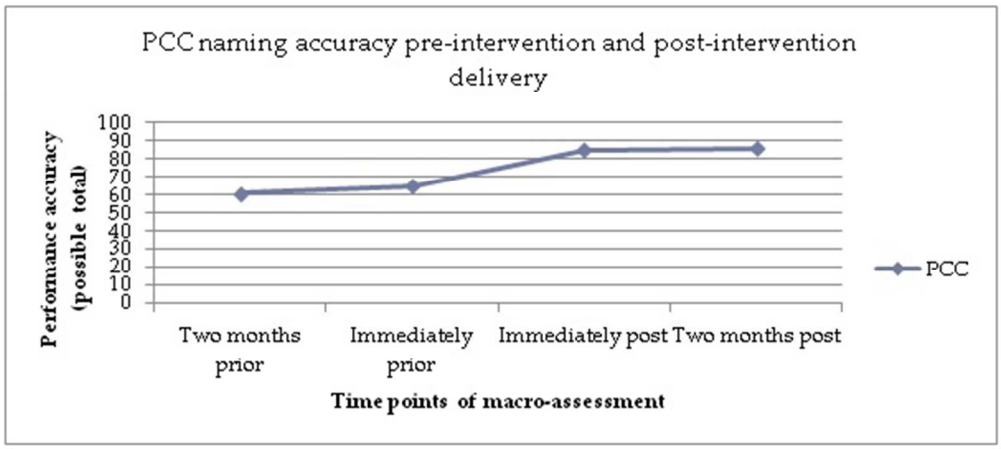

Figure 3 Comparison of Harry's performance in naming task scored for the Percentage of Consonants Correct (PCC) at baseline pre-intervention and post-intervention delivery

160x71mm (96 x 96 DPI)

Appendix 1 Probe assessment items

	treated		untreated		not targeted controls		distinctive controls	
Phase 1 Phonological								
SIWI	['supɐ]	soup	[soko'lɐtɐ]	chocolate	[zɐ'cɐtɐ]	jacket		
	['sinɐfo]	cloud	[sɐ'kulɐ]	bag	['zɐxɐɾi]	sugar		
	[sɐli'gɐɾi]	snail	[su'vlɐci]	skewer	['zoɐ]	animals		
SIWW	[cɛ'ɾɐsi]	cherry	['mɛlisɐ]	bee	['vɐzo]	vaze		
	[pu'kɐmiso]	shirt	[musi'ci]	music	[ku'zinɐ]	kitchen		
	['mɐjisɐ]	witch	[tilɛ'oɾɐsi]	TV	[mɛ'zuɾɐ]	meter		
Phase 2 Morphological								
/s/SFWF FGS	[çɛ'lonɐs]	turtle's	[o'bɾɛlɐs]	umbrela	['mɛlisɛs]	bees	[mo'ɾu]	baby's
	[kuku'vɐjɐs]	owl's	['kotɐs]	hen	['bluzɛs]	blouzes	[kɐ'pɛlo]	hat's
	[ɐjɛ'lɐðɐs]	cow's	['ɣɐtɐs]	cat	[o'bɾɛlɐs]	umberelas	['milu]	apple's
/s/SFWF MAP	[ɛ'lɛfɐdɛs]	elephants	[kɐɾxɐ'ɾiɛs]	sharks	[pɐpɐ'ɣɐlos]	parrot	[pɐpɐ'ɣɐlon]	parrots'
	['kokoɾɛs]	roosters	['mɐjiɾɛs]	cooks	['likos]	woolf	['likon]	woolves's
	['ɐdɾɛs]	men	[ɐɛ'tus]	eagles	[lɐ'ɣos]	rabbit	[lɐ'ɣon]	rabbits's
Phase 3 Phonological								
/sk/ WI	['skɐlɐ]	ladder	['skɐvi]	digs	[stɐ'fili]	grape	['tɾɛno]	train
	['skɐci]	chess	[skɐ'dzoçiɾos]	hedgehog	['stomɐ]	mouth	['tɾɛçi]	run
	[sku'lici]	worm	['scilos]	dog	[stɛ'fɐni]	crown	['tɾoi]	eat
/sk/WW	['pɾoskopo]	scout	[vo'skos]	shepherd	['fustɐ]	skirt	[jɐ'tɾos]	doctor
	[kɐ'skol]	scarf	[bi'skoto]	biscuit	[ɐsti'nomos]	policeman	['vɐtɾɐxos]	frog
	[fu'skono]	blow	['mɐskɐ]	mask	[mu'stɐci]	mustache	['citɾino]	yellow
/ks/ WI	[ksɐ'plono]	lie	[ksɐci'nɐo]	start	['psɐɾi]	fish		
	[ksi'fiɐs]	swordfish	['ksifos]	sword	[psɐ'liði]	scissors		
	['ksilo]	wood	[ksi'ɾɐfi]	razor	['psino]	grill		
/ks/ WW	[ɛkso'çi]	countryside	['ɐmɐksɐ]	carriage	[ɐ'popsɛ]	tonight		
	['miksɐ]	snot	['ɐniksi]	spring	['jipso]	plaster		
	[ɐ'mɐksi]	car	[mɐksi'lɐɾi]	pillow	[tɐ'psi]	pan		
Phase 4 Morphological								
/ks/ / simple past morpheme	['ðjɐlɛksɛ]	chose	['pɛtɐksɛ]	threw	['ɐnɐpsɛ]	lit	[ci'mɐtɛ]	is sleeping
	['fonɐksɛ]	shouted	['ɐniksɛ]	opened	['ɛkopsɛ]	cut	['plɛnɛtɛ]	is washed
	['ɛpɛksɛ]	played	['tiliksɛ]	wrapped	['ɛvɐpsɛ]	painted	[xtɛ'nizɛtɛ]	is combed

Appendix 2 Sample activities used during the intervention sessions

Sample activity 1

Target: update of stored motor programmes in the word stem: the production of /s/ in WISI position.

Pictures of words are presented, for the child to name each one. If /s/ WISI is accurately produced, activity continues. If /s/ production is inaccurate corrective feedback is given on positioning of the articulators. If the second attempt is inaccurate then a model is given for the child to imitate.

Sample activity 2

Target: update of stored motor programmes in the word suffix: elicited production of feminine nouns in genitive case in singular number.

Pictures of feminine nouns (i.e. /ɐjɛˈlɐðɐ/ cow) are presented and a carrier phrase (this tail is…whose?) is used to elicit production in genitive (/ɐjɛˈlɐðɐs/ cow's). If both case and /s/ suffix are accurately produced activity continues. If genitive case is not produced, the need for the noun to be in genitive is explained. If /s/ production is inaccurate, corrective feedback is given on positioning of the articulators.

Sample activity 3

Target: Auditory discrimination of nominative-genitive case in the word suffix

Pairs of stimuli identical or differing by case suffix (/ɐjɛˈlɐðɐ/-/ɐjɛˈlɐðɐs/cow-cow's) are auditory presented. The child is asked to decide if the stimuli heard were same or different. If the decision is correct, activity continues. If the child fails to discriminate the therapist repeats the pair with prolonged duration of /s/. If the child fails twice, visual and tactile information is used as corrective feedback.