

Research Report

Phonological and articulation treatment approaches in Portuguese children with speech and language impairments: a randomized controlled intervention study

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Abstract

Background: In Portugal, the routine clinical practice of speech and language therapists (SLTs) in treating children with *all* types of speech sound disorder (SSD) continues to be articulation therapy (AT). There is limited use of phonological therapy (PT) or phonological awareness training in Portugal. Additionally, at an international level there is a focus on collecting information on and differentiating between the effectiveness of PT and AT for children with different types of phonologically based SSD, as well as on the role of phonological awareness in remediating SSD. It is important to collect more evidence for the most effective and efficient type of intervention approach for different SSDs and for these data to be collected from diverse linguistic and cultural perspectives.

Aims: To evaluate the effectiveness of a PT and AT approach for treatment of 14 Portuguese children, aged 4.0–6.7 years, with a phonologically based SSD.

Methods & Procedures: The children were randomly assigned to one of the two treatment approaches (seven children in each group). All children were treated by the same SLT, blind to the aims of the study, over three blocks of a total of 25 weekly sessions of intervention. Outcome measures of phonological ability (percentage of consonants correct (PCC), percentage occurrence of different phonological processes and phonetic inventory) were taken before and after intervention. A qualitative assessment of intervention effectiveness from the perspective of the parents of participants was included.

Outcomes & Results: Both treatments were effective in improving the participants' speech, with the children receiving PT showing a more significant improvement in PCC score than those receiving the AT. Children in the PT group also showed greater generalization to untreated words than those receiving AT. Parents reported both intervention approaches to be as effective in improving their children's speech.

Conclusions & Implications: The PT (combination of expressive phonological tasks, phonological awareness, listening and discrimination activities) proved to be an effective integrated method of improving phonological SSD in children. These findings provide some evidence for Portuguese SLTs to employ PT with children with phonologically based SSD.

Keywords: phonologically based speech sound disorders, phonology, articulation, intervention, effectiveness, children.

What this paper adds*What is already known on the subject?*

Phonological therapy (PT) and traditional articulation therapy (AT) have been shown to be effective in remediating phonologically based speech sound disorder (SSD) in children speaking English.

What this paper adds

PT and AT were found to be effective in improving phonologically based SSD in children speaking European Portuguese as their main language, with the phonological approach being the more effective of the two. Since traditional AT is the most typical form of intervention in Portugal for children with *all* SSDs, these results have the potential to provide SLTs in Portugal with empirical evidence regarding the relative benefit of PT versus AT for children with SSD.

Introduction

Children with phonologically based speech sound disorder (SSD) are reported to present with difficulties in their phonology, which can be observed by the number of phonological processes evident in their speech (Beers 1992, Roberts *et al.* 1998, Bortolini and Leonard 2000, Orsolini *et al.* 2001, Mediavilla *et al.* 2002, Bree 2007). The majority of these phonological processes signal a delay in development, because they occur in the early stages of normally developing children. Unusual patterns not typically seen in normal development have also been reported (Beers 1992, Mediavilla *et al.* 2002, Bree 2007).

A phonologically based SSD has also been associated with poor phonological awareness and with later literacy problems (Catts 1991, Bird *et al.* 1995, Stothard *et al.* 1998, Gillon 2000a, Snowling *et al.* 2000, Catts *et al.* 2002, Rvachew *et al.* 2003, Botting *et al.* 2006). Thus, it is crucial that speech and language therapists (SLTs) work on expressive phonological skills and phonological awareness in order to support the underlying skills for literacy in children with phonologically based SSD (Gillon 2000b, 2004).

Intervention approaches for speech sound disorder (SSD)

For many years the most typical treatment approach for children with SSD was the traditional articulation approach (Van Riper 1939). In this approach the overall goal is for children to learn how to articulate individual phonemes to improve the intelligibility of their speech (Baker 2006). Ingram's (1976) work changed the focus of the problem from an articulation disorder (focus on individual sounds) to a phonological disorder (focus on patterns of speech sounds). Consequently, this change in focus transformed the assessment and management of SSD. Assessment now routinely includes a phonologically based analysis by identifying patterns of difficulty (e.g. /g/ produced as [d] and /k/ produced as [t] indicating the same error pattern, i.e. fronting), and phonological process analysis (Baker 2006). The focus of

intervention is typically no longer on individual speech sound production, usually targeting one sound at a time, but rather it focuses on the elimination of error patterns and the change of the child's phonological system through a process of phonological generalization. For this reason, as part of phonological therapy (PT), SLTs work with groups of sounds in words, as children with phonologically based SSD are seen to have a linguistic problem with the organization and use of phonemes to signal meaning rather than a more motoric or structural difficulty which an articulation disorder might suggest (Baker 2006). There is also a range of procedural differences which differentiate articulation therapy (AT) from PT, including differences in use of strategies, therapy activities, treatment words and feedback (Bernthal *et al.* 2008).

However, in Portugal, where this study was conducted, observational reports suggest that the routine clinical practice to date of SLTs in treating children with *all* SSDs continues to be AT. There is limited awareness or use of PT or phonological awareness training in Portugal and speech and language therapy students in Portugal are trained during their clinical placements to use the traditional articulation approach for all children with SSD. At an international level, information on the effectiveness of PT and AT for children with phonologically based SSD, and the role of phonological awareness in remediating SSD, is growing. It is important to know more about what type of intervention approach is effective for which disorder, and to build as strong an evidence base as possible for a chosen intervention (Joffe 2008, Baker and McLeod 2011).

There are different therapies in use for children with phonologically based SSD (Joffe and Pring 2008, Baker and McLeod 2011), e.g. auditory discrimination (Berry and Eisenson 1956), minimal opposition contrast therapy (Weiner 1981), AT (Van Riper and Emerick 1984), cycles approach (Hodson and Paden 1991), Metaphon (Howell and Dean 1991), and phonological awareness (Gillon 2000b).

There is an ongoing need to assess and compare the effectiveness and efficiency of interventions that SLTs

report to use in their current practice, e.g. articulation versus PT (Joffe and Pring 2003, 2008).

Auditory discrimination, minimal contrast therapy and phonological awareness were identified as the most popular intervention approaches used by SLTs in clinical practice for children with SSD in a survey in the UK, with more than 50% of respondents always or often using them on their own or in combination (Joffe and Pring 2003, 2008). The 'popularity' of minimal contrast therapy has been reported more recently in a narrative review of intervention studies published from 1979 to 2009 for children with SSD (Baker and McLeod 2011). Out of a total of 134 intervention studies included in the review, 46 distinct intervention approaches for SSD were identified, with 23 of them described in more than one publication. Of these 23 intervention approaches, minimal pair intervention was the most commonly cited treatment approach and was associated with 42 of the studies reported (Baker and McLeod 2011). The effectiveness of each of these approaches needs to be investigated to ensure that clinical practice mirrors research findings.

Gillon (2000a, 2000b) demonstrated that children, aged between 5.6 and 7.6 years with a phonologically based SSD benefitted from phonological awareness intervention. The phonological awareness intervention in Gillon's studies focused on developing phonological awareness at the phoneme level. The aim was to facilitate change in phonological skills by targeting the child's awareness of the contrastive nature of sounds whilst also working on production of sound patterns. The intervention proved to be an effective method of resolving the children's speech production errors and also improved phonological awareness and reading ability (Gillon 2000b). In this study, a comparison was made between phonological intervention in combination with phonological awareness versus a more 'traditional articulation' approach. Children who were treated with a phonological awareness intervention (which included a focus on increasing phonological awareness and grapheme–phoneme correspondence knowledge, as well as providing appropriate opportunities for speech production), showed greater improvement than children treated with a 'traditional articulation intervention' that focused predominantly on resolving speech sound errors without any phonological awareness work (Gillon 2000b). In contrast, Hesketh *et al.* (2000), in a study that also compared AT with metaphonological therapy (focusing on both general phonological awareness activities and on more specific awareness activities involving their target phonemes/processes), but with younger children (between 3.6 and 5.0 years), concluded that the two therapy groups made the same amount of progress in speech production as measured by the percentage of consonants correct (PCC) score, with the

children from the AT group making more progress on one measure of speech improvement—a naming task. Unlike Gillon (2000b), they found no advantage for the group receiving metaphonological therapy. There are some key methodological differences in these two studies which may account for some of the variations in outcomes. First, the participants in Gillon's (2000b) study were older than those in Hesketh *et al.*'s (2000) study and may therefore have had more exposure to the alphabet and been better equipped to utilize the information provided in the phonological awareness intervention, which incorporated grapheme–phoneme correspondence knowledge. Second, Gillon's (2000b) phonological awareness approach included opportunities for speech production, in conjunction with the phonological awareness work. In contrast, Hesketh *et al.* (2000) included production only in the final 2 weeks of the intervention programme, and during this period children were not explicitly corrected on their speech attempts *per se*, but rather were given more general feedback on the phonological features of their utterances. And third, Gillon's (2000b) articulation approach was a 'phoneme-orientated approach', targeting individual phonemes using Van Riper's (1939) traditional articulation approach. Hesketh *et al.*'s (2000) 'articulation therapy', in contrast, targeted either phonemes or classes of phonemes and processes and therefore appeared to be more phonologically based.

There are other studies comparing articulation versus phonological intervention that found PT to be more effective than traditional AT (Klein 1996, Pamplona *et al.* 1999). Klein (1996) compared the efficacy and efficiency of PT with traditional AT in the treatment of children (between 3.0 and 5.10 years) with SSD. Children in the PT group showed significantly more improvement and in a shorter period of time than children in the traditional therapy group. Pamplona *et al.* (1999) also compared PT with AT in a randomized control trial with children with cleft palate, between the ages of 3.1 and 7.1 years, with compensatory articulation disorder (CAD). The focus of this study was on overall efficiency, i.e. the total time of speech therapy (taken from onset of speech therapy to complete normalization of the disorder) required for correcting the CAD. The mean total time of speech intervention required to remediate the CAD in the phonological treatment group was less than half the amount of time (14.50 months) than that required for the articulation treatment group (30.07 months). These results show that the overall speech therapy time was significantly reduced when using a phonological treatment approach compared with an articulatory method, and provides evidence to suggest that PT is more efficient than traditional AT.

Teutsch and Fox (2004) reported four case studies (aged between 3.10 and 4.2 years) with a consistent

phonological disorder. Two children were treated with PT and the other two with a traditional articulation approach. The results suggested that PT promoted better progress in children's phonological abilities (measured in PCC and percentage of phonological processes) than the AT.

Considering the evidence, it is apparent that both approaches can be effective in improving speech for children with SSD. Most of the studies, however, have shown PT to be more effective than AT. Despite this finding traditional AT is the approach most typically used in Portugal to treat children with all SSDs (including articulation disorders, consistent and inconsistent phonological disorders) and it is this use of AT across all clinical cases in Portugal that motivated the development of this study to compare the effectiveness of PT and traditional AT in European Portuguese-speaking children with phonologically based SSD.

Aims of the study

The primary aim was to explore the effectiveness of two types of interventions to treat phonologically based SSD in a group of 14 pre- or early school-age children (aged from 4.0 to 6.7 years) with speech and language impairments using a randomized control intervention study design: an AT (van Riper and Emerick 1984) and a PT, which combined phonological awareness therapy (Gillon and McNeill 2007) and listening and discrimination activities (Lancaster 2008). The study tested the effectiveness of AT, the conventional intervention in Portugal for children with phonologically based SSD and compared it with a PT approach, an intervention based on phonological principles and used internationally (McLeod 2007). The two interventions had different selected targets (PT focused on sound patterns, AT on single sounds) and procedural differences, including different instructions, therapy activities and feedback.

It was predicted that: (1) children in both treatment groups would improve, in line with previous studies demonstrating the effectiveness of both approaches (Klein 1996, Gillon 2000b, Hesketh *et al.* 2000); and (2) the PT group would show greater improvement than the AT group (as measured by PCC and a generalization probe) as the former approach focuses on phonological contrasts, rather than on individual sounds, which has been shown to promote generalization and a change in the overall phonological system (Baker and McLeod 2004, Baker 2006).

Method

Participants

A group of 14 Portuguese children (ten boys and four girls) with phonologically based SSD, with a mean age

of 62.21 months (standard deviation (SD) = 11.00 months), was recruited through local SLTs. Prior to the start of the project they were diagnosed as having phonologically based SSD after extensive assessment by an SLT, an audiologist and a psychologist. Subject selection criteria included: greater than 1.5 SD below the mean on the Teste de Avaliação da Linguagem na Criança (TALC), a standardized receptive and expressive language test (Kay and Tavares 2007);¹ audition of 20 dB or lower in the frequencies 500, 1000 and 2000 Hz; an absence of social or emotional problems; and no obvious neurological damage. Children diagnosed with childhood apraxia of speech were also excluded. Non-verbal ability (NVIQ) was assessed with the Performance Scale of the Wechsler Preschool and Primary Scale of Intelligence—Revised (WPPSI-R) (Wechsler 2003).² All 14 participants showed a discrepancy, of at least 1 SD, between language skills and NVIQ, with language always lower. Some children ($n = 6$) had non-verbal abilities within the average range (above 85) and can be viewed as having specific language impairment (SLI) (Leonard 1998) while the remaining eight had an NVIQ ranging between 85 and 62 and therefore showed more general language learning difficulties (for characteristics of the participants, see table 1). All ethical procedures were ensured and informed consent was collected from all carers prior to any data collection.

Pre-treatment assessments

The children's phonological abilities were assessed by the first author with a single-word naming (67 words) phonetic–phonological test (TFF-ALPE³) standardized on Portuguese children (Mendes *et al.* 2009, Lousada *et al.* 2012). This phonetic–phonological test provides the context to test and analyse all sounds in different word positions and also includes the following phonological processes for analysis: final consonant deletion, weak syllable deletion, cluster reduction, gliding of liquids, stopping, fronting, depalatalization, backing, palatalization, and devoicing. Recordings were made in a sound-treated room using a Cirrus Research MK224 microphone located 1 m in front of the child's mouth.⁴ The children's realizations were transcribed phonetically based on perceptual and acoustic analysis (Shriberg and Lof 1991) using the Speech Filing System (SFS) Release 4.7/ Windows (Huckvale *et al.* 1987). These transcriptions were annotated on four levels: the target of the phonetic transcription using SAMPA (Wells 1997) alphabet (first level); the child's actual production, transcribed phonetically using SAMPA alphabet (second level); the target of the syllabic structure, using the code C for consonants and V for vowels (third level); and the child's syllabic

Table 1. Characteristics of participants: gender, age (months), non-verbal intelligence (NVIQ) (standard score), receptive language (raw score), expressive language (raw score) and intervention group

Child	Gender	Age (months)	NVIQ (mean = 100, SD = 15)	Receptive language	Expressive language	Intervention group
CA	F	50	117	61 WNL	30 < 2 SD	PT
AM	M	64	66	63 WNL	28 < 3 SD	PT
MR	F	48	89	55 WNL	28 < 3 SD	PT
LA	F	62	83	64 WNL	22 < 4 SD	PT
DM	M	79	109	64 WNL	44 < 1.5 SD	PT
AD	F	50	82	58 WNL	3 < 8 SD	PT
RM	M	64	62	62 WNL	33 < 3 SD	PT
JC	M	77	63	65 WNL	26 < 5 SD	AT
MS	M	48	85	55 WNL	26 < 3 SD	AT
RF	M	57	84	53 < 1.5 SD	24 < 4 SD	AT
DG	M	63	87	62 WNL	28 < 3 SD	AT
FP	M	75	66	57 < 2 SD	22 < 8 SD	AT
AP	M	75	66	58 < 2 SD	22 < 8 SD	AT
TM	M	59	116	55 WNL	21 < 4 SD	AT
Mean (SD)		62.21 (11.00)	83.93 (18.96)			

Note: WNL, within normal limits.

structure using the same codes of the third level (fourth level).

Reliability

The first author (an SLT) carried out the phonetic annotations and transcriptions of all children. In addition, the production of all isolated words of one randomly selected child⁵ from both pre- and post-treatment points was annotated and transcribed by a trained SLT not involved in the study and blind to its aims. Point-to-point reliability was 90.3% (pre-treatment assessment) and 93.7% (post-treatment assessment). These values are comparable with those reported in other studies in disordered child phonology (Shriberg and Lof 1991, Shriberg *et al.* 1999) and were considered adequate for the objective of this study.

Intervention

The children were randomly assigned following simple randomization procedures (computerized random numbers) to one of two treatment groups (seven children in each group). Seven children were treated individually with an AT, and their progress compared with a group of seven children treated with a PT (table 1).

An analysis of variance (ANOVA) was used to compare the PCC, receptive language, expressive language, NVIQ and age of the groups before the therapy and showed that at pre-treatment there were no significant differences between groups in PCC ($F[1,12] = 0.304$, $p = 0.592$), receptive language ($F[1,12] = 2.346$, $p = 0.152$), expressive language ($F[1,12] = 2.120$, $p =$

0.171), NVIQ ($F[1,12] = 0.316$, $p = 0.584$), and age ($F[1,12] = 0.795$, $p = 0.390$).

The intervention for both groups consisted of 25 weekly sessions (individual) of 45 min in duration, divided into three blocks (9 + 8 + 8 weeks) without any breaks. Both groups were treated by the same SLT (blind to the aims of the study) in order to minimize the influence of some confounding variables. The SLT was trained in both intervention approaches by the first author. The study took place at the University of Aveiro. The children did not receive other forms of intervention or special education during the intervention period.

One phonological rule (for PT) or one phoneme (for AT) was chosen as intervention targets by the first author for each block. Target processes or phonemes were selected according to: the frequency of use of phonological processes (processes with a percentage of occurrence above 40% were prioritized for therapy) (Hodson and Paden 1991); stimulability of speech sounds (stimulable sounds were a priority for therapy);⁶ the effect on intelligibility; and the sequence of normal development (Dodd and Bradford 2000). The sequence of normal sound development was determined by the ages of phonetic acquisition and ages of elimination of phonological processes available for European Portuguese-speaking children (Lousada *et al.* 2012).

Phonological therapy (PT)

PT consisted of a combination of phonological awareness activities and auditory discrimination and listening tasks. The items used in the phonological awareness activities were based on the child's target speech production goals, e.g. children with fronting

as their phonological process were introduced to the target sound (/k/) and the substituted sound (/t/) using letter knowledge activities to allow for minimal pair therapy (Gillon and McNeill 2007). The PT included phonological awareness activities from Gillon and McNeill's (2007) programme (letter–sound knowledge, phoneme identity and phoneme matching, blending, segmentation, and phoneme manipulation). Activities chosen were age appropriate and reflected the developmental stage of the child. During the activities the SLT gave corrective feedback when the child made a speech error. For example, 'when you say "so" I can't hear the last sound. Sol (sun) has three sounds s...o...l' (segmenting the word and placing out three blocks to represent the three sounds). 'Try saying sol with three sounds...sol' (touching each block to correspond with each sound in the word). As is evident from this example, emphasis was placed on the production of speech sounds, as was the case in one of the intervention approaches (the phoneme awareness intervention with integrated speech sound production) described by Tyler *et al.* (2011) and as outlined in Gillon (2005).

During the first two sessions of each block the focus was on listening and discrimination activities (Lancaster 2008) and for the remaining sessions the focus was on the phonological awareness intervention program. During the phonological awareness activities the productions of the target sound were elicited in each activity, as suggested by Gillon and McNeill (2007). During letter–sound knowledge and phoneme manipulation activities, minimal pairs were also used following Gillon and McNeill's (2007) procedures. For an example of a 'Letter Sound Knowledge' activity utilized in the study, see appendix A.

Examples of the listening and discrimination activities relating to the children's error patterns (Lancaster 2008), also included in the PT, are presented in appendix A.

Articulation therapy (AT)

AT consisted of a traditional AT approach that aims to develop the child's ability to discriminate and articulate the target sound correctly in isolation, syllables, words, phrases and sentences, following the 'Van Riper Method' (van Riper and Emerick 1984). The first two sessions of each block focused on sensory perceptual training and the remaining sessions on production. Therapy was undertaken on one target sound at a time. Different activities were used during the sensory–perceptual training (e.g. detect sound errors in the clinician's speech). Direct instruction in the mechanism of phoneme production was used through techniques such as progressive approximation and phonetic placement (e.g. instructing the children where to place the articulators to produce a

specific sound, providing opportunities for children to watch the clinician's tongue movements and to imitate them).

Similar pictures were used across different games (e.g. puzzles and bingo) for both interventions to enhance the children's attention and motivation. The words used in the two interventions were mostly monosyllabic or dissyllabic and had simple syllabic structures except when the target was a structure-changing process related with the CCV and CVC structures.

Generalization probe

After each block of intervention, a generalization probe of the trained sound or phonological process to five non-intervention words was used. The probes were carefully chosen and each child (no matter what group) had the same number of opportunities (i.e. five) to produce the correct target. The non-intervention words, which were related to the intervention words (e.g. had the sound/process targeted during the therapy), were matched to the intervention words on syllable number and on frequency (e.g. two familiar words of animals were used: the word 'galo' (cock) during the intervention and the word 'gata' (cat) as a non-intervention word). Pictures were used to elicit a spontaneous production. This task determined if the child generalized the targeted speech skill and provided important insight into the impact of intervention on a child's phonological system (Baker and McLeod 2004).

Post-treatment assessment

After 25 sessions of therapy, the children were assessed by the first author with the same single-word phonetic–phonological test (Mendes *et al.* 2009) used at the pre-treatment phase.⁷

Treatment fidelity

To analyse the fidelity of the treatment, the first author (SLT1) and another SLT (SLT2, blind to the therapy given) separately observed six treatment sessions each (three of AT and three of PT) and filled in an observational rating scale recording key elements: duration of session; target sound(s); type of reinforcement used; type of intervention; and main activities used. A list of activities was provided (e.g. letter–sound knowledge, phoneme identity and phoneme matching, blending, listening and discrimination activities, production practice of a sound in isolation; production practice of a sound in syllables), and the SLTs selected what they observed). SLT2 was instructed to observe the session and complete the questionnaire about the session (e.g. activities and duration).

Table 2. Percentage consonant correct (PCC) at the pre- and post-treatment assessment for phonological (PT) and articulation therapy (AT) groups

		PCC		
		Pre-treatment	Post-treatment	Change score: pre to post
PT group ($n = 7$)	Mean	49.04	67.23	18.18
	Minimum–maximum	16.04–73.80	35.29–89.30	7.49–27.81
	SD	22.89	20.83	6.15
AT group ($n = 7$)	Mean	42.93	50.42	7.41
	Minimum–maximum	21.39–71.66	28.88–77.01	0.54–19.79
	SD	18.35	19.02	6.06

Qualitative assessment

A questionnaire was developed to evaluate the effectiveness of each intervention from the perspective of the participants' parents in order to enhance the ecological validity of the results. Areas explored included speech improvement, enjoyment of intervention sessions and the impact of intervention on intelligibility.

Outcome measures

To compare the results of the two groups at pre- and post-intervention points the PCC score (primary outcome),⁸ the percentage occurrence of different phonological processes and phonetic inventory (secondary outcomes) were calculated for all participants. The PCC score was calculated by dividing the number of consonants produced correctly by the number of target phonemes and multiplied by 100. The percentages of each type of phonological process were also calculated by applying the same rule: frequency of phonological process type divided by the total number of occurrences in which the process could occur multiplied by 100. Formulas and functions to extract automatically these percentages were developed using a Microsoft Office Excel spreadsheet.

Data analysis

Non-parametric tests were used initially to compare data between groups because of the small sample size. However, some parametric analyses were used where equivalent non-parametric tests were unavailable (e.g. two-factor analyses). Since results from the one-factor non-parametric analyses were in agreement with the one-factor parametric analyses, and to maintain consistency throughout the paper, we only present parametric tests for all analyses. The level of significance used was 0.05.

Additionally, size effects were calculated and interpreted using Cohen's statistic d for a two-samples t -test (Cohen 1988, Kinnear and Gray 2004) and the par-

tial η^2 coefficient for the ANOVA tests (Clark-Carter 1997, Kinnear and Gray 2004).

Results

PCC scores for PT and AT groups

The PCC score was calculated at pre- and post-treatment for the PT and AT groups. The range of PCC scores obtained at pre-intervention spanned from 16.04% to 73.80% (mean = 49.04%, SD = 22.89) for children in the PT group and from 21.39% to 71.66% (mean = 42.93%, SD = 18.35) in the AT group. Change scores for PCC from pre- to post-treatment were also calculated (table 2).

Statistical analyses were then used to compare the scores for PCC from pre- to post-treatment in the PT and AT groups. Paired t -tests showed significant differences in the PT group ($t(6) = 7.820$, $p = 0.000$; $d = 2.96$, representing a large effect size; Cohen 1988) and in the AT group ($t(6) = 3.321$, $p = 0.016$; $d = 1.26$ representing a large effect) pre- to post-treatment, with both groups improving significantly from pre- to post-treatment. In addition, change scores were compared between the two groups. A significant difference in PCC change scores between groups was found [$t(12) = 3.299$, $p = 0.006$; $d = 1.76$ representing a large effect), with the children receiving PT showing a more significant improvement than the AT group.

The analysis of variance (two-way ANOVA) also showed a significant PCC effect, which indicate that all children improved from pre- to post-treatment ($F[1,12] = 62.825$, $p \leq 0.001$, partial $\eta^2 = 0.840$, representing a large effect size ($\eta_p^2 > 0.1$)). Furthermore, there was a significant group by time interaction effect ($F[1,12] = 10.905$, $p \leq 0.01$, partial $\eta^2 = 0.476$, representing a large effect size ($\eta_p^2 > 0.1$)) with the PT group making significantly greater progress than the AT group over time (figure 1). These differential results suggest that the improvement was a consequence of therapy and not a result of maturation. There was no significant group

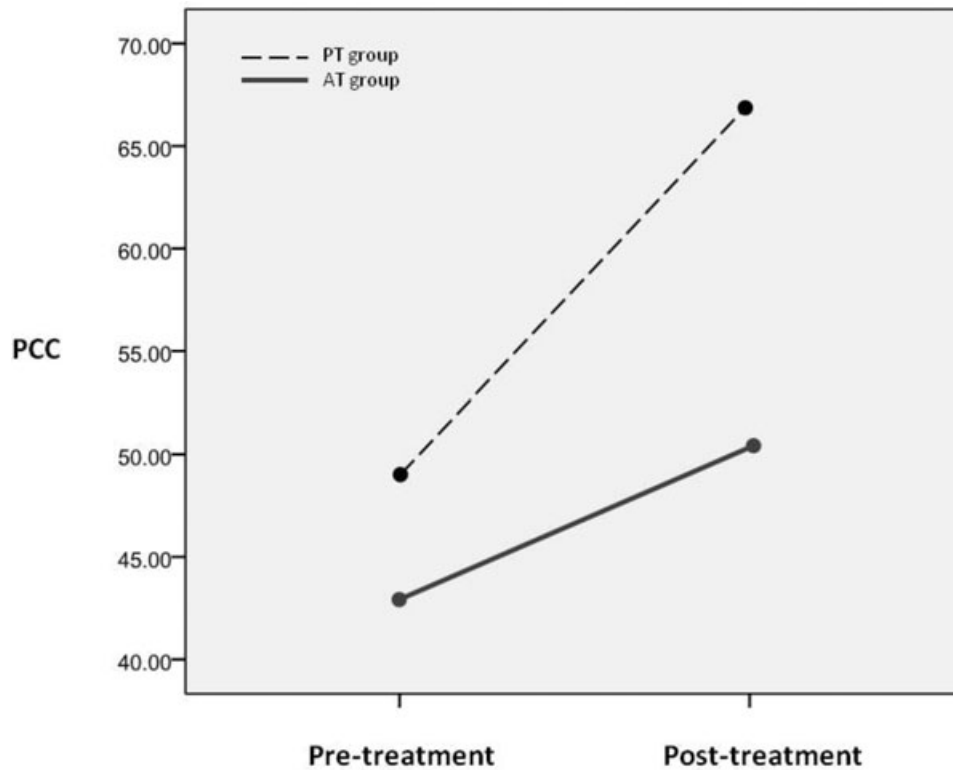


Figure 1. PCC scores at pre- and post-treatment for PT and AT groups.

effect ($F[1,12] = 1.135, p = 0.308, \text{partial } \eta^2 = 0.086$, representing a medium effect ($0.01 < \eta_p^2 < 0.1$)).

Phonological processes and PCC for each child

The phonological processes used by children in the PT and AT groups at pre- and post-treatment assessment are summarized in tables 3 and 4, respectively. For PT children the target processes are signalled with an asterisk (*) and for AT children the target sounds and sounds added to the phonetic inventory after therapy are also identified.

Overall, the results obtained for children in the PT group showed a decrease in the percentages of the occurrence of different phonological processes after the intervention, especially in target phonological processes (table 3). For children AM, AD and RM, the percentage of occurrence of one of the three target processes did not change. Interestingly, AM and AD had the lowest PCC scores of all children at pre-treatment assessment (16.04% and 19.79%, respectively). The phonological process that did not change (devoicing) in child RM involves two sounds that were not stimulable at pre-treatment assessment.

The results also showed that some phonological processes increased after the treatment. However, on closer

inspection it becomes clear that this is because of an overall improvement in speech. AM, for example, at pre-treatment eliminated many weak syllables pre-tonic (59.1%) and post-tonic (73.6%). After the treatment, these processes decreased substantially because he used many more weak syllables. His use of cluster reduction (CR) increased, however, from pre- to post-intervention because of his use of the CV instead of the CCV syllabic structure. This explains the increase of the CR process after therapy (e.g. at pre-treatment the child produced [ti] for the word [tigɾi] and at post-treatment the child produced [tigɾi] for the same word).

Results for children in the AT group showed that for three children (JC, MS and FP) one or two target sounds were added to the phonetic inventory after the therapy but other non-target sounds were also added. For one child (DG) there were no added sounds (target or non-target) and for two children (AP and TM) only one non-target sound was added to the phonetic inventory. An exception was RF, where sounds added were exactly the same sounds that were targeted during the intervention. Interestingly, this was the only child in the AT group that did not present any atypical phonological processes and had the highest PCC score (71.66%) at pre-treatment assessment (table 4). For JC some generalization of the trained fricative to other untrained fricatives was also observed.

Table 3. Percentage of occurrence of phonological processes and PCC at pre- and post-treatment assessments for PT group

Child	Pre-treatment		Post-treatment	
	Phonological processes and PCC	Phonetic inventory	Phonological processes and PCC	Added sounds
CA	GL (21.1%); FRON (3.4%); BACK (3.8%); PAL (10.0%); *DEV /z, ʒ/ (100%); *FCD /l, r/ (57.9%); WSDpre (13.6%); WSDpost (1.89%); CR (84.2%); *CDS /r/ (100%); PCC (67.91%)	/p, t, k, b, d, g, m, n, ʃ, f, s, j, v, l/	GL (26.3%); FRON (0%); BACK (0%); PAL (0%); *DEV /z, ʒ/ (0%); *FCD /r/ (36.8%); WSDpre (9.1%); WSDpost (0%); CR (78.9%); *CDS /r/ (0%); PCC (75.40%)	/ʒ, ʎ, r/
AM	STOP (12.1%); *FCD /l, r, ʃ/ (71.4%); WSDpre (59.1%); WSDpost (73.6%); CR (26.3%); *CDS /d, g/ (35.3%); *FS /s, f/ (43.8%); PCC (16.04%)	/p, t, k, b, d, m, s, v, r/	STOP (18.2%); FRON (6.9%); BACK (3.8%); *FCD /l, r, ʃ/ (71.4%); WSDpre (36.4%); WSDpost (52.8%); CR (68.4%); *CDS /d, g/ (17.7%); *FS /s, f/ (18.8%); PCC (35.29%)	/g, n, f, ʃ, z, l/
MR	GL (26.3%); STOP (3%); DEP (23.5%); *DEV /z, ʒ/ (83.3%); *FCD /l, r/ (35.7%); WSDpre (27.3%); CR (84.2%); *CDS /f/ (77.8%); PCC (59.36%)	All except /ʒ, ʎ, r/	GL (5.3%); *DEV /z, ʒ/ (50%); *FCD /l, r/ (32.1%); WSDpre (9.1%); CR (57.9%); *CDS /f/ (0%); PCC (75.94%)	/ʒ/
LA	*GL /l/ (42.1%); DEV (33.3%); *FCD /l, r/ (52.6%); WSDpre (22.7%); *CR /br, tr, pr, fr, gr, dr, kr, vr/ (63.2%); PCC (73.80%)	All except /ʎ/	*GL /l/ (10.5%); DEV (50%); *FCD /l, r/ (0%); WSDpre (13.6%); *CR /br, dr / (10.5%); PCC (89.30%)	no added sounds
DM	GL (5.3%); STOP (9.1%); FRON (10.3%); BACK (26.9%); DEP (29.4%); DEV (83.3%); *FCD /l, r, ʃ/ (85.7%); WSDpre (22.7%); *CR /br, tr, pr, fr, gr, dr, kr, vr, pl, kl, fl/ (100%); *ICD /d, g/ (94.1%); PCC (46.52%)	/p, t, k, b, m, n, ʃ, f, s, j, v, l, ʎ/	GL (10.5%); STOP (3.0%); DEV (83.3%); *FCD /l, r/ (42.9%); WSDpre (4.5%); *CR /br, tr, pr, fr, gr, dr, kr, vr/ (68.4%); *ICD /d, g/ (5.9%); PCC (74.33%)	/d, g, z, r, R/
AD	GL (21.1%); STOP (6.1%); *FRON /k/ (26.3%); BACK (7.7%); DEV (33.3%); FCD (28.6%); WSDpre (22.7%); CR (31.6%); *CDS /d, g/ (64.7%); *FS /f, s/ (81.3%); PCC (19.79%)	/p, t, k, b, d, m, s, j, v, l, R/	GL (15.8%); STOP (6.1%); *FRON /k/ (15.8%); BACK (0%); DEV (83.3%); FCD (50%); WSDpre (31.8%); CR (68.4%); *CDS /d, g/ (64.7%); *FS /f, s/ (50%); PCC (40.11%)	/n, ʃ/
RM	*DEV /z, ʒ/ (100%); *FCD /l, r/ (94.7%); WSDpre (13.6%); CR /br, tr, pr, fr, gr, dr, kr, vr, pl, kl/ (73.7%); *ICD /g/ (60.0%); PCC (59.89%)	/p, t, k, b, d, g, m, n, ʃ, f, s, j, v, l, R/	*DEV /z, ʒ/ (100%); *FCD (52.6%); WSDpre (13.6%); CR /br, tr, gr, dr/ (21.1%); *ICD /g/ (0%); PCC (80.21%)	/r/

Note: CR, cluster reduction; FCD, final consonant deletion; DEV, devoicing; WSDpre, weak syllable deletion pre-tonic; GL, gliding of liquids; STOP, stopping; FRON, fronting; DEP, depalatalization; WSDpost, weak syllable deletion post-tonic; BACK, backing; PAL, palatalization; ICD, initial consonant deletion (deletion of the initial stop); CDS, initial consonant deletion or substitutions (atypical deletions or substitutions, e.g. some consonants [d, g] were deleted or substituted in initial syllable position); FS, atypical fricative substitutions, e.g. /f/ produced as [s]. The target processes are signalled with an asterisk (*).

Table 4. Percentage of occurrence of phonological processes, PCC, target sounds and new sounds at pre- and post-treatment assessments for the AT group

Child	Pre-treatment			Post-treatment		
	Phonological processes	Phonetic inventory	Target sounds	Phonological processes	Added sounds	
JC	GL (10.5%); STOP (36.4%); BACK (23.1%); FCD (96.4%); WSDpre (45.5%); CR (78.9%); ICD of /t, d/ (65.4%); PCC (31.02%)	/p, k, b, g, m, n, ʃ, v, R/	/t, d, f/	GL (26.3%); STOP (3.0%); BACK (7.7%); FCD (67.9%); WSDpre (36.4%); CR (68.4%); ICD of /t, d/ (61.5%); PCC (39.57%)	/t, f, s, ʃ/	
MS	GL (30%); FRON (3.4%); PAL (20.0%); DEV (33.3%); FCD (53.6%); WSDpre (18.2%); CR (78.9%); CDS (40.7%); PCC (50.80%)	/p, t, k, b, d, g, m, n, ʃ, f, s, ʃ, v, l, r/	/g, R, ʌ/	GL (35%); FRON (3.4%); DES (11.8%); BACK (3.8%); PAL (10%); DEV (16.7%); FCD (35.7%); WSDpre (18.2%); CR (84.2%); CDS (7.4%); PCC (70.59%)	/z, ʒ, ʌ, R/	
RF	GL (100%); PAL (10.0%); DEV (83.3%); FCD (57.1%); WSDpre (22.7%); CR (73.7%); PCC (71.66%)	/p, t, k, b, d, g, m, n, ʃ, f, s, ʃ, v, l, R/	/z, ʒ, ʌ/	GL (0%); PAL (0%); DEV (33.3%); FCD (39.3%); WSDpre (9.1%); CR (68.4%); PCC (77.01%)	/z, ʒ, ʌ/	
DG	GL (10.5%); STOP (3.0%); FRON (10.3%); DEV (100%); FCD (28.6%); WSDpre (86.4%); CR (63.2%); ICD (40%); PCC (54.01%)	All except /z, ʒ/	/g, z, ʒ/	GL (15.8%); STOP (3.0%); FRON (17.2%); DEV (100%); FCD (32.1%); WSDpre (22.7%); CR (57.9%); ICD (20%); PCC (57.75%)	no added sounds	
FP	STOP (15.2%); FRON (37.9%); DEP (11.8%); FCD (75.0%); WSDpre (45.5%); CR (68.4%); CDS (30.4%); PCC (23.53%)	/p, t, k, b, d, g, m, n, f, s, v, ʌ, /	/R, g, ʃ/	STOP (15.2%); FRON (41.4%); DEP (11.8%); BACK (3.8%); DEV (33.3%); FCD (78.6%); WSDpre (31.8%); WSDpost (34.0%); CR (84.2%); CDS (26.1%); PCC (29.95%)	/ʃ, l/	
AP	GL (5.3%); STOP (6.1%); FRON (20.7%); DEP (5.9%); BACK (3.8%); FCD (71.4%); WSDpre (22.7%); WSDpost (58.5%); CR (36.8%); CDS (50%); PCC (21.39%)	/p, t, k, b, d, g, m, f, s, v, l/	/R, g, ʃ/	STOP (9.1%); FRON (34.5%); DEP (17.6%); BACK (3.8%); DEV (33.3%); FCD (85.7%); WSDpre (18.2%); WSDpost (30.2%); CR (73.7%); CDS (40%); PCC (28.88%)	/n/	
TM	GL (31.6%); STOP (3.0%); FRON (3.4%); DEV (16.7%); FCD (82.1%); WSDpre (27.3%); CR (78.9%); CDS (61.5%); PCC (48.13%)	/p, t, k, b, d, g, m, n, f, s, ʃ, v, ʒ, l, ʌ, /	/R, g, ʒ/	GL (5.3%); STOP (12.1%); FRON (3.4%); DEV (16.7%); FCD (75.0%); WSDpre (22.7%); CR (63.2%); CDS (46.7%); PCC (49.20%)	/r/	

Note: CR, cluster reduction; FCD, final consonant deletion; DEV, devoicing; WSDpre, weak syllable deletion pre-tonic; GL, gliding of liquids; STOP, stopping; FRON, fronting; DEP, depalatalization; WSDpost, weak syllable deletion post-tonic; BACK, backing; PAL, palatalization; ICD, initial consonant deletion (deletion of the initial stop); CDS, consonant deletion or substitutions (atypical deletions or substitutions).

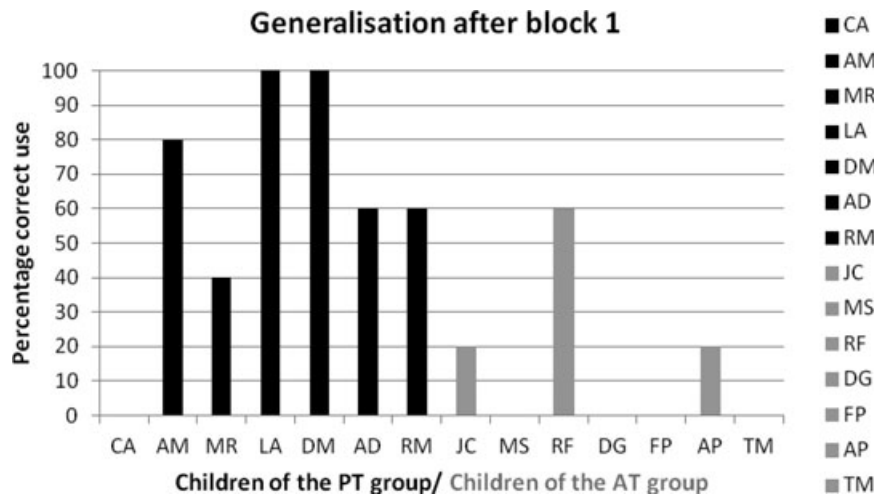


Figure 2. Generalization to non-intervention words after block 1 (the percentage corresponds to the number of words where the target was correctly produced).

Generalization probe

The generalization to untreated words after block 1 (figure 2) was more substantial for children in the PT group than for children in the AT group. In the PT group, five children achieved substantial levels of generalization (60% for two children, 80% for one child and 100% for two children); for the other two children the levels of generalization were 0% and 40%. In the AT group one child presented with substantial changes (60%); for two children the generalization was smaller (20%); and generalization was not observed at all (0%) for the remaining four children.

After block 2, generalization probe data revealed that four children in the PT group (the same four of five children who scored high after block 1) achieved over 50% generalization. For the other three children in this group the generalization observed was smaller (<50%). In the AT group, two children presented with large amounts of generalization (>50%), three children did not show any generalization and for two children the levels of generalization observed were smaller (20%) (figure 3).

After block 3, the same four children in the PT group who scored high after blocks 1 and 2 presented with substantial changes (>50%), for one child the generalization was smaller (40%), and for two children generalization was not observed. In the AT group for two children the levels of generalization reached were substantial (>50%), for one child the generalization was smaller at 40% and for four children generalization was not observed (figure 4).

Fidelity of treatment

Close agreement was observed in the reports provided by both SLTs⁹ (SLT1, SLT2 who was blind to the ther-

apy given) about the intervention that was planned and described in the method for the following parameters: session duration (45 min); target sounds (selected according to individual child's needs); type of intervention (randomly assigned to AT or PT); activities that were the focus of the session (dependent on the type of intervention); type of reinforcement (planned to be similar for every child). Of the six sessions observed, 100% concordance was obtained across all elements observed. This agreement in observations by SLT1 and SLT2 of what was planned and what took place allows it to be concluded that the target interventions were administered as intended and reported, thus fidelity of treatment was high, and, consequently, ensure a good internal and external validity of this study (Resnick *et al.* 2005).

Parental reports: qualitative assessment

The parent questionnaire focused on the following areas: speech improvement; enjoyment of therapy; and the effect of therapy on their understanding of their child. All parents reported that the intervention given had contributed to the improvement of their children's speech, and that their children enjoyed the therapy. Eleven of 14 parents reported a better understanding of their child after the therapy. Three parents (21.4%) reported the same level of understanding pre- and post-therapy. There were no differences in parental reports across the two treatment approaches.

Discussion

This study investigated the effectiveness of two types of treatment approaches for remediating phonologically

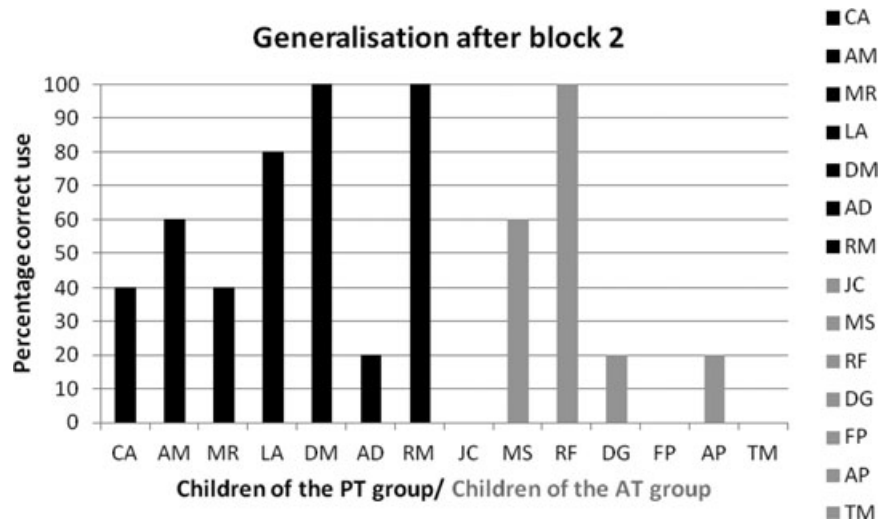


Figure 3. Generalization to non-intervention words after block 2 (the percentage corresponds to the number of words where the target was correctly produced).

based SSD, PT and AT, in 14 children with speech and language impairments. There were no significant differences in PCC scores, receptive language, expressive language, NVIQ, and age between the two groups before treatment. PCC scores from pre- to post-treatment showed significant improvements in both the PT and AT groups, with large effect sizes, showing that both approaches were effective in improving speech. However, the PT group made significantly better progress on PCC scores than the AT group, indicating that PT was more effective than AT, and supporting the findings of previous studies (Klein 1996, Pamplona *et al.* 1999, Gillon 2000b, Teutsch and Fox 2004). Also, whilst both treatments were effective, the PT group improved faster (in same period) and this may indicate that PT was more efficient than AT, as shown by Pamplona *et al.* (1999).

This finding could be due to the different focus of the two therapies: individual sounds in the case of AT, and sound patterns in PT. Other differences in the two approaches that could have influenced the findings include the specific therapy activities, feedback given and elicitation strategies used (Berntal *et al.* 2008). It is important to note, however, that such differences, wherever possible, were avoided and the therapies were delivered, as far as possible, in as uniform a way, whilst still adhering to the principles of either AT or PT, e.g. same SLT, same pictures, same structure (three blocks and each block having a different intervention target).

It is possible that children improved due to maturation and we do not have a control group to eliminate this possibility fully. However, the group by time interaction effect—indicating that, whilst the group as a

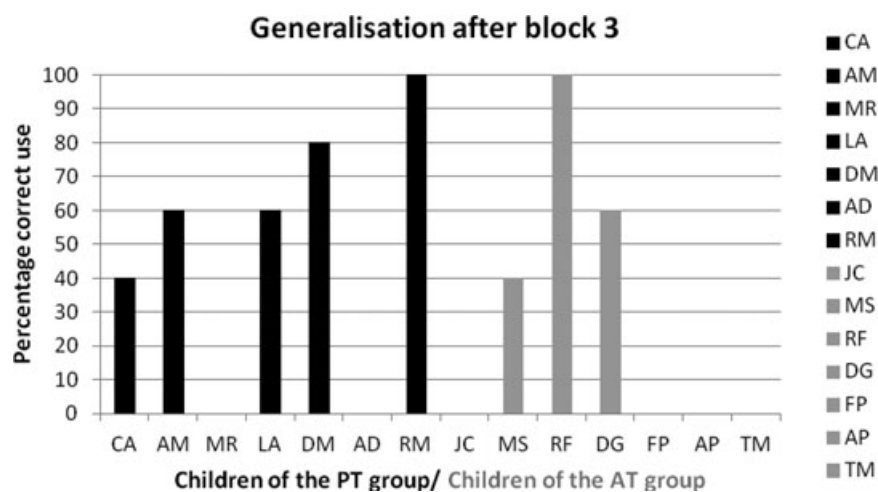


Figure 4. Generalization to non-intervention words after block 3 (the percentage corresponds to the number of words where the target was correctly produced).

whole improved from pre- to post-treatment, the PT group made significantly more progress over time than the AT group—reduces this possibility.

The results for phonological processes and PCC scores obtained for each child showed that the response to intervention was not equal for all children across the three blocks. Differences in progress for children receiving the same intervention therapy with the same SLT were also observed in a previous study (Baker and McLeod 2004). Baker and McLeod (2004) observed that different children needed different amounts of therapy to achieve generalization and suggested that some differences between children (e.g. motivation and expressive language skills) might influence response to intervention. It is important that further research gives more attention to differential responses to treatment considering the recent focus on the relationship between dosage, frequency and intensity of intervention and its effectiveness (Warren *et al.* 2007).

It has also been suggested that mild SSD may have a better prognosis than more severe disorders (Smit 2004). Despite the two groups being matched at pre-intervention on PCC, there were individual differences across the groups and PCC at pre-intervention may have had an impact on response to treatment, e.g. in the PT group, AM and AD had the lowest PCC scores and, as observed previously, one of the target processes for both children did not change. In the AT group, RF who demonstrated a good response to the intervention was the child with the highest PCC score of this treatment group at pre-treatment assessment. Another variable that may have influenced the response to intervention is the presence of atypical phonological processes. In the AT group, RF, who showed better progress than all other children in this group, was the only child in the group that did not use atypical phonological processes at pre-treatment assessment.

The generalization probe to non-intervention words, used after each block, indicated that many children from the PT group (five children after block 1 and four children after blocks 2 and 3) made substantial and potentially long-standing changes as they generalized to untreated words. Children from the AT group did not show as much generalization to untreated words (only one child after block 1 and 2 children after blocks 2 and 3 presented with substantial levels of generalization).

Every parent reported that the intervention had contributed to the improvement of their child's speech, and that the therapy helped them to understand their children better. These parental views support the findings of the study: a significant difference was shown in the PT and in the AT group pre- to post-treatment, and are important in that they provide insights into the perspectives of the family regarding the intervention. The parents also reported that their children enjoyed the

therapy. The use of attractive materials and fun games during the sessions for both therapy groups probably contributed to this finding. These parental reports by their very nature are subjective, and one could argue are more positively biased since their children are receiving intervention and they are being questioned by a SLT. It is however important to explore the views of parents, and even the children themselves (Rvachew and Nowak 2001), in order to get a more functional perspective of the impact of the therapy, despite it being challenging to establish a sufficiently robust tool.

The results obtained with the generalization probe provide insight into the impact of the interventions on the child's phonological system (Baker and McLeod 2004). However, we did not have baseline data for the generalization probes, therefore these results must be viewed with some caution.

The findings from the current study support Dodd and Bradford's (2000) conclusions that an articulation approach alone does not have any major impact on the speech production of children with phonological impairment as this approach focuses on individual speech sound production and not on the elimination of error patterns. They are different to those of Hesketh *et al.* (2000) who found that children receiving AT and those receiving metaphonological therapy made the same amount of progress in PCC scores. In our study both groups improved on PCC score, however the PT group improved more. A possible explanation for this difference could be due to the children's age differences across the two studies. Hesketh *et al.* included younger children (mean age = 48.13, SD = 5.72) than those included in the current study (mean age = 62.21, SD = 11.00).

The findings of this study also support the results obtained by Gillon (2000b) that children receiving phonological awareness intervention make better progress in speech production than children receiving traditional articulation intervention. Interestingly, the participants in the Gillon study were also older than those in Hesketh *et al.* (2000).

Some processes with occurrences of less than 40%, and not directly targeted by the intervention, were also reduced or eliminated after therapy, particularly after the PT intervention. For example, for DM, a child from the PT group, fronting, depalatalization and backing were eliminated (table 3). This was also observed in other children (e.g. four processes were eliminated during CA's therapy in spite of these processes not being directly targeted). These findings support Hodson and Paden's (1991) claim that processes that were less frequent than 40% could disappear without direct intervention.

For RM (PT group), during the first block of therapy the sounds /r/ and /l/ were targeted in syllable final position for the target process 'final consonant deletion'.

At the final assessment this child also used these sounds in CCV syllables, e.g. in the words 'três' (three) and 'planta' (plant) and consequently the process of 'cluster reduction' also decreased (table 3). This is evidence for generalization of the sounds used in therapy to other syllabic structures and was only observed after PT therapy.

With regards to DG (AT group), it could be argued that his difficulties in expressive language adversely influenced his response to treatment as suggested by Baker and McLeod (2004). However, RM (PT group) also demonstrated similar expressive language skills (and other similar characteristics in pre-intervention assessment comparative to DG), and made better progress, so it seems more likely that the differences in response to intervention of these children can be attributed to the differences in the two approaches.

Conclusions

In summary, the results obtained suggest that PT and AT were both effective in enhancing children's speech production. However, PT was found to be more efficient than AT. The use of phonological awareness activities that were selected based on individual children's speech sound error patterns (Gillon and McNeill 2007) in combination with listening and discrimination activities that were also selected taking into account the children's error patterns (Lancaster 2008) proved to be an effective integrated approach to developing phonological abilities in children with phonologically based SSD. This finding provides some evidence for the effectiveness of an intervention approach, which included the three elements that practising therapists in the UK reported to include in their routine intervention with children with phonologically based SSD: auditory discrimination, phonological contrast therapy and phonological awareness (Joffe and Pring 2008).

Thus, this randomized controlled intervention study adds important evidence for the effectiveness of speech and language therapy with children with phonologically based SSD. The study was completed with European Portuguese-speaking children in Portugal, where the most common type of therapy for all children with SSD is AT, and therefore has the potential to provide SLTs in Portugal with evidence regarding the benefit of PT versus AT for children with SSD.

The sample size used (seven children in each group) is too small, however, to produce any definite conclusions and further research is needed with a larger sample. Also, some heterogeneity of participants (e.g. with respect to age, language ability and speech sound production) across and within the groups could have impacted on the results.

This study helped to answer the question about the most effective and efficient treatment for children with phonologically based SSD. Phonological intervention that included phonological awareness activities and, simultaneously, activities that helped children to be conscious about their error patterns was the most effective in remediating phonologically based SSD. Others, however, have found that PT without phonological awareness is an effective intervention approach (Dodd and Bradford 2000). It will be interesting to explore in future if the significant gains made by the PT group would still have occurred without the additional phonological awareness component. These findings provide some initial support for Portuguese therapists to employ PT with clients with phonologically based SSD. It would be useful to survey more formally the SLT practices of Portuguese SLTs working with children with SSD, as has been done by others in different countries (Baker and McLeod 2008, Joffe and Pring 2008), as much of the information at this point is anecdotal. Future studies should also explore the effectiveness and efficiency of PT and AT for children with different types of SSD.

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Appendix A: Examples of activities used in phonological therapy

Letter-sound knowledge: letter matching at the start of a word (Gillon and McNeill 2007: 24)

Example for stopping (i.e. target sound = initial /s/).

Place three speech cards with the words written underneath on the floor, one which starts with the child's target letter.

Clinician: 'Find the word that starts with a /s/ sound. "sol" (sun), "mão" (hand), "pato" (duck).'

Child: 'sol' (sun).

Clinician: 'Well done! You found the s at the start of "sol" (sun). "Sol" (sun) starts with a /s/ sound. Say "sol" (sun) with me.'

Puzzle (Lancaster 2008: 143)

Example for cluster reduction

Target sound /pʁ/.

Contrast: /p/.

Words: 'prato' (dish), 'pato' (duck).

Resources: enlarged pictures of a dish and duck that are cut into pieces; a bag in which the puzzle pieces are kept.

Activity: The child finds a piece of the puzzle that represents the name of the object. 'Find a bit of dish' or 'Find a bit of duck'. Say the naming word a couple of times in a row to keep the child listening. The activity is repeated until the puzzles are complete.

Notes

1. The standardization of the TALC included 580 European Portuguese-speaking children. This test was used since it is the only test available to assess receptive and expressive language in European Portuguese pre-school-age children.
2. The results were obtained with the Portuguese standardization of this test ($N = 1352$). The WPPSI-R is considered a reliable and valid assessment for Portuguese children (Seabra-Santos *et al.* 2003).
3. TFF-ALPE is the only standardized instrument to assess phonetic and phonological abilities in European Portuguese-speaking children and is considered a valid and reliable instrument (Mendes *et al.* 2009, Lousada *et al.* 2012).
4. The signal was preamplified (Cirrus Research MV 181 A) and then amplified and filtered by a cirrus Research ZE 901B Preamplifier Power Supply. The acoustic signal was recorded using a Marantz PMD671 solid-state recorder, with 16 bits and a sampling frequency of 48 kHz.
5. One child represents 7% of speech samples and this percentage is comparable with what is reported when checking reliability in other efficacy studies (e.g. Dodd and Bradford 2000, Crosbie *et al.* 2005).
6. An informal assessment of stimulability was used since in Portugal there are no standardized measures to assess this.
7. Although some test words (13%) were not avoided as treatment words, this did not influence the comparative analysis of effectiveness since they were used in both treatment approaches.
8. This measure was used since it is one of the outcome measures widely used to analyse the efficacy of intervention (Hesketh *et al.* 2000, Braun and Fox 2003, Crosbie *et al.* 2005).
9. None of these SLTs provided any treatment.

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