Phonological and articulation treatment approaches in Portuguese children with speech and language impairments: a randomised 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. There is limited use of phonological therapy 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 phonological and articulation therapy 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 speech sound disorders (SSDs) and for this data to be collected from diverse linguistic and cultural perspectives.

Aims: This study evaluates the effectiveness of a phonological therapy (PT) and articulation therapy (AT) approach for treatment of 14 Portuguese children, aged 4.0-6.7 years, with a phonologically-based SSD.

Methods and Procedures: The children were randomly assigned to one of the two treatment approaches (7 children in each group). All children were treated by the same Speech and Language Therapist (SLT), blind to the aims of the study, over 3 blocks of a total of 25 weekly sessions of intervention. Outcome measures of phonological ability (percentage of consonants correct (PCC) score, the 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 and 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 generalisation to untreated words than those receiving AT. Parents reported both intervention approaches to be as effective in improving their children's speech.

Conclusions and Implications: The phonological therapy (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 phonological therapy with children with phonologically-based SSD.

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

What we know

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

What this paper adds

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

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 focuses on the elimination of error patterns and the change of the child's phonological system through a process of phonological generalisation. For this reason, as part of phonological therapy, 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 are also a range of procedural differences which differentiate articulation therapy from phonological therapy, 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* speech sound disorders (SSDs) continues to be articulation therapy. There is limited awareness or use of phonological therapy or phonological awareness training in Portugal and SLT 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 phonological and articulation therapy for children with phonologically-based SSD, and the role of phonological awareness in remediating speech sound disorder 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), for example, auditory discrimination (Berry and Eisenson, 1956), minimal opposition contrast therapy (Weiner, 1981), articulation therapy (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, for example, articulation versus phonological therapy (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 (2000b, 2000a) 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 (Gillon, 2000b, 2000a). 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 articulation therapy 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 articulation therapy 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 study (200b) were older than those in Hesketh et al's study (2000) and may therefore have had more exposure to the alphabet and been better equipped to utilise 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 two 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 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 phonological therapy to be more effective than traditional articulation therapy (Klein, 1996, Pamplona et al., 1999). Klein (1996) compared the efficacy and efficiency of phonological therapy with traditional articulation therapy in the treatment of children (between 3.0 and 5.10 years) with SSD. Children in the phonological therapy 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 phonological therapy with articulation therapy in a randomised control trial with children with cleft palate, between the ages of 3.1 – 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 normalisation 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 to an articulatory method, and provides evidence to suggest that phonological therapy is more efficient than traditional articulation therapy.

Teutsch and Fox (2004) reported four case-studies (aged between 3.10 – 4.2 years) with a consistent phonological disorder. Two children were treated with phonological therapy and the other two with a traditional articulation approach. The results suggested that phonological therapy promoted better progress in children's phonological abilities (measured in PCC and percentage of phonological processes) than the articulation therapy.

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 phonological therapy to be more effective than articulation therapy. Despite this finding traditional articulation therapy 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 articulation therapy across all clinical cases in Portugal that motivated the development of this study to compare the effectiveness of phonological therapy and traditional articulation therapy in Portuguese-speaking children with phonologically-based SSD.

Aims of the study

The primary aim of this study 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 randomised control intervention study design: an articulation therapy (AT) (Van Riper and Emerick, 1984) and a phonological therapy (PT), that combined phonological awareness therapy (Gillon and McNeill, 2007) and listening and discrimination activities (Lancaster, 2008). The study tested the effectiveness of articulation therapy, the conventional intervention in Portugal for children with phonologically-based SSD and compared it with a phonological therapy approach, an intervention based on phonological principles and used internationally (McLeod, 2007). The two interventions had different selected targets (phonological therapy focused on sound patterns, articulation therapy 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); 2) the phonological therapy group would show greater improvement than the articulation therapy group (as measured by PCC, and generalisation probe) as the former approach focuses on phonological contrasts, rather than on individual sounds, which has been shown to promote generalisation and a change in the overall phonological system (Baker and McLeod, 2004, Baker, 2006).

Method

Participants

A group of 14 Portuguese children (10 boys and 4 girls) with phonologically-based SSD, with a mean age of 62.21 months (standard deviation (SD) = 11.00) was recruited through local SLTs. Prior to the start of the project they were diagnosed as having phonologically-based SSD after extensive assessment by a Speech and Language Therapist (SLT), an audiologist and a psychologist. Subject selection criteria included: greater than 1.5 standard deviation (SD) below the mean on the Teste de Avaliação da Linguagem na Criança (TALC), a standardised receptive and expressive language test (Kay and Tavares, 2007)[1]; audition of 20dB or lower in the frequencies 500Hz, 1000Hz and 2000Hz; an absence of social or emotional problems and 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 8 had NVIQ ranging between 85 and 62 and therefore showed more general language learning difficulties (see Table 1 for characteristics of the participants). The study was conducted with the approval of the local and national ethics committees and informed consent was collected from all carers prior to any data collection.

PUT TABLE 1 ABOUT HERE

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[1] The standardisation of the TALC included 580 European-Portuguese 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 standardisation of this test (N=1352). The WPPSI-R is considered a reliable and valid assessment for European-Portuguese children (Seabra-Santos et al., 2003).

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-ALPE[3]) standardised on Portuguese children (Mendes et al., 2009). 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 metre in front of the child's mouth[4]. The children's realisations 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 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 structure using the same codes of the third level (fourth level).

Reliability

The first author, (a SLT) carried out the phonetic annotations and transcriptions of all children. In addition, the production of all isolated words of 1 randomly selected child[5] from

[3] TFF-ALPE is the only standardised instrument to assess phonetic and phonological abilities in European-Portuguese children and is considered a valid and reliable instrument (Mendes et al., 2009).
[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 to what is reported when checking reliability in other efficacy studies (for example, Dodd and Bradford, 2000, Crosbie et al., 2005).

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 to 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 (7 children in each group). Seven children were treated individually with an AT, and their progress compared with a group of 7 children treated with a PT (see 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 minutes in duration, divided into 3 blocks (9 weeks + 8 weeks + 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 in Portugal.

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 prioritised 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 children (Mendes et al., 2009).

The Phonological Therapy

The 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) program (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

[6] An informal assessment of stimulability was used since in Portugal there are no standardised measures to assess this.

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 2 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. See the appendix for an example of a 'Letter Sound Knowledge' activity utilised in the study.

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

Articulation Therapy

The AT consisted of a traditional articulation therapy 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 2 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, 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.

Generalisation probe

After each block of intervention, a generalisation 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 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 6 treatment sessions each (3 of AT and 3 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, duration, etc.).

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.

[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.

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 automatically extract 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 (for example, 2-factor analyses). Since results from the 1-factor non-parametric analyses were in agreement with the 1-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 two samples t test (Cohen, 1988, Kinnear and Gray, 2004) and the Partial eta-squared coefficient for the ANOVA tests (Clark-Carter, 1997, Kinnear and Gray, 2004).

[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).

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 (see Table 2).

PUT TABLE 2 ABOUT HERE

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 η^2 = 0.840, representing a large effect size (η_p^2 > 0.1). Furthermore, there was a significant group by time interaction effect (F [1,12] = 10.905, $p \leq 0.01$; Partial η^2 = 0.476, representing a large effect size (η_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 effect (F [1,12] = 1.135, p = 0.308 Partial eta-squared = 0.086, representing a medium effect (0.01 < η_p^2 < 0.1)).

PUT FIGURE 1 ABOUT HERE

Phonological processes and PCC for each child

The phonological processes used by children in the PT and AT group at pre and post-treatment assessment are summarised in Tables 3 and 4, respectively. For PT children the target processes are signalled with the symbol (*) 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 percentages of occurrence of different phonological processes after the intervention, especially in target phonological processes (see 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 [tigɾɨ] and at post-treatment the child produced [tigɨ] for the same word).

PUT TABLE 3 ABOUT HERE

Results for children in the AT group showed that for 3 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 (see Table 4). For JC some generalisation of the trained fricative to other untrained fricatives was also observed.

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Generalisation probe

The generalisation to untreated words after block 1 (see Figure 2) was more substantial for children in the PT group than for children in the AT group. In the PT group, 5 children achieved substantial levels of generalisation (60% for 2 children, 80% for one child, and 100% for 2 children); for the other 2 children the levels of generalisation were 0% and 40%. In the AT group 1 child presented with substantial changes (60%), for 2 children the generalisation was smaller (20%) and generalisation was not observed at all (0%) for the remaining 4 children.

PUT FIGURE 2 ABOUT HERE

After block 2, generalisation probe data revealed that 4 children in the PT group (the same 4 of 5 children who scored high after block 1), achieved over 50% generalisation. For the other 3 children in this group the generalisation observed was smaller (< 50%). In the AT group, 2 children presented with large amounts of generalisation (> 50%), 3 children did not show any generalisation and for 2 children the levels of generalisation observed were smaller (20%) (see Figure 3).

PUT FIGURE 3 ABOUT HERE

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 1 child the generalisation was smaller (40%) and for 2 children, generalisation was not observed. In the AT group for 2 children the levels of generalisation reached were substantial (> 50%), for 1 child the generalisation was smaller at 40% and for 4 children generalisation was not observed (see Figure 4).

PUT FIGURE 4 ABOUT HERE

Fidelity of treatment

Close agreement was observed in the reports provided by both SLTs[9] (SLT1; SLT2 - blind to the therapy given) about the intervention that was planned and described in the method for the following parameters: session duration (45 minutes); 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 6 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 us to conclude that the

[9] None of these SLTs provided any treatment.

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 fourteen 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-based SSD, phonological therapy and articulation therapy, 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 articulation therapy, sound patterns in phonological therapy. Other differences in the two approaches that could have influenced the findings include the specific therapy activities, feedback given and elicitation strategies used (Bernthal 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, for example, same SLT, same pictures, same structure (3 blocks and each block having a different intervention target).

It is possible that children improved due to maturation and we don't have a control group to eliminate this possibility fully. However, the group by time interaction effect, indicating that, whilst the group as a 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 generalisation 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, for example, 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 generalisation 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 generalisation to untreated words (only one child after block 1 and 2 children after blocks 2 and 3 presented with substantial levels of generalisation).

Every parent reported that the intervention had contributed to the improvement of their child's speech, and that the therapy helped them to better understand their children. 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 been 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 generalisation 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 generalisation 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 articulation therapy and those receiving mataphonological 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.* (2000) 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*'s study.

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 (see Table 3). This was also observed in other children (e.g., 4 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 /ɾ/ 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, for example in the words "t**r**ês" (three) and "p**l**anta" (plant) and consequently the process of 'cluster reduction' also decreased (see Table 3). This is evidence for generalisation 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 articulation and phonological therapies were both effective in enhancing children's speech production. However, the 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 randomised 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 Portuguese-speaking children in Portugal, where the most common type of therapy for all children with SSD is articulation therapy, and therefore has the potential to provide SLTs in Portugal with evidence regarding the benefit of phonological versus articulation therapy for children with SSD.

The sample size used (7 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 (for 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 phonological therapy without phonological awareness is an effective intervention approach (Dodd and Bradford, 2000). It will be interesting to explore in the 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 phonological therapy with clients with phonologically-based SSD. It would be useful to survey more formally the SLT practices of Portuguese Speech and Language Therapists 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

Examples of Activities used in the Phonological Therapy

1. **Letter sound knowledge: Letter matching at the start of a word (Gillon and McNeill, 2007, p.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".

2. **Puzzle (Lancaster, 2008, p.143)**

Example for cluster reduction

Target sound /pɾ/

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.

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	Below 2 SD	PT
AM	M	64	66	63	WNL	28	Below 3 SD	PT
MR	F	48	89	55	WNL	28	Below 3 SD	PT
LA	F	62	83	64	WNL	22	Below 4 SD	PT
DM	M	79	109	64	WNL	44	Below 1.5 SD	PT
AD	F	50	82	58	WNL	3	Below 8 SD	PT
RM	M	64	62	62	WNL	33	Below 3 SD	PT
JC	M	77	63	65	WNL	26	Below 5 SD	AT
MS	M	48	85	55	WNL	26	Below 3 SD	AT
RF	M	57	84	53	Below 1.5 SD	24	Below 4 SD	AT
DG	M	63	87	62	WNL	28	Below 3 SD	AT
FP	M	75	66	57	Below 2 SD	22	Below 8 SD	AT
AP	M	75	66	58	Below 2 SD	22	Below 8 SD	AT
TM	M	59	116	55	WNL	21	Below 4 SD	AT
Mean (Standard deviation)		62.21(11.00)	83.93 (18.96)					

Abbreviation: WNL - within normal limits.

Table 2. Percentage Consonant Correct (PCC) at the pre-treatment and post-treatment assessment for Phonological (PT) and Articulation Therapy (AT) groups.

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

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

	Pre-treatment		Post-treatment	Added sounds
Child	Phonological processes and PCC	Phonetic inventory	Phonological processes and PCC	
CA	GL (21.1%); FRON (3.4%); BACK (3.8%); PAL (10.0%); *DEV /z, ʒ/ (100%); *FCD /l, ɾ/ (57.9%); WSDpre (13.6%); WSDpost (1.89%); CR (84.2%); *CDS /ʀ/ (100%); PCC (67.91%)	/p, t, k, b, d, g, m, n, ɲ, f, s, ʃ, v, l/	GL (26.3%); FRON (0%); BACK (0%); PAL (0%); *DEV /z, ʒ/ (0%); *FCD /ɾ/ (36.8%); WSDpre (9.1%); WSDpost (0%); CR (78.9%); *CDS /ʀ/ (0%); PCC (75.40%)	/ʒ, ʎ, ʀ/
AM	STOP (12.1%); *FCD /l, ɾ, 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, ʀ/	STOP (18,2%); FRON (6.9%); BACK (3.8%); *FCD /l, ɾ, 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, ɾ/ (35.7%); WSDpre (27.3%); CR (84.2%) *CDS /f/ (77.8%); PCC (59.36%)	All except /ʒ, ʎ, ɾ/	GL (5.3%); *DEV /z, ʒ/ (50%); *FCD /l, ɾ/ (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, ɾ/ (52.6%); WSDpre (22.7%); *CR /bɾ, tɾ, pɾ, fɾ, gɾ, dɾ, kɾ, vɾ/ (63.2%); PCC (73.80%)	All except /ʎ/	*GL /l/ (10.5%); DEV (50%); *FCD /l, ɾ/ (0%); WSDpre (13.6%); *CR / bɾ, dɾ / (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, ɾ, ʃ/ (85.7%); WSDpre (22.7%); *CR /bɾ, tɾ, pɾ, fɾ, gɾ, dɾ, kɾ, vɾ, pl, kl, fl/ (100%); *ICD /d, g/ (94.1%); PCC (46.52%)	/p, t, k, b, m, n, ɲ, f, s, ʃ, v, l, ʎ/	GL (10.5%); STOP (3.0%); DEV (83.3%); *FCD /l, ɾ/ (42.9%); WSDpre (4.5%); *CR /bɾ, tɾ, pɾ, fɾ, gɾ, dɾ, kɾ, vɾ/ (68.4%); *ICD /d, g/ (5.9%); PCC (74.33%)	/d, g, z, ɾ, ʀ/
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/	/p, t, k, b, d, m, s, ʃ, v, l, ʀ/	GL (15.8%); STOP (6.1%); *FRON /k/ (15.8%); BACK (0%); DEV (83.3%); FCD (50%); WSDpre (31.8%); CR (68.4%); *CDS	/n, ɲ/

	(64.7%) *FS /f, s/ (81.3%); PCC (19.79%)		/d, g/ (64.7%) *FS /f, s/ (50%); PCC (40.11%)	
RM	*DEV /z, ʒ/ (100%); *FCD /l, ɾ/ (94.7%); WSDpre (13.6%); CR /bɾ, tɾ, pɾ, fɾ, gɾ, dɾ, kɾ, vɾ, pl, kl/ (73.7%); *ICD /g/ (60,0%); PCC (59.89%)	/p, t, k, b, d, g, m, n, ɲ, f, s, ʃ, v, l, ʀ/	*DEV /z, ʒ/ (100%); *FCD (52.6%); WSDpre (13.6%); CR /bɾ, tɾ, gɾ, dɾ/ (21.1%); *ICD /g/ (0%); PCC (80.21%)	/ɾ/

Key process abbreviations: 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 the symbol (*).

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

	Pre-treatment			Post-treatment	
Child	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, ɲ, 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, ɲ, f, s, ʃ, v, l, ɾ/	/g, R, ʎ/	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, ʎ, 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, ɲ, f, s, ʃ, v, l, R/	/z, ʒ, ʎ/	GL (0%); PAL (0%); DEV (33.3%); FCD (39.3%); WSDpre (9.1%); CR (68.4%); PCC (77.01%)	/z, ʒ, ʎ/
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, ʎ,/	/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, ʎ,/	/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%)	/ɾ/

Key process abbreviations: 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).

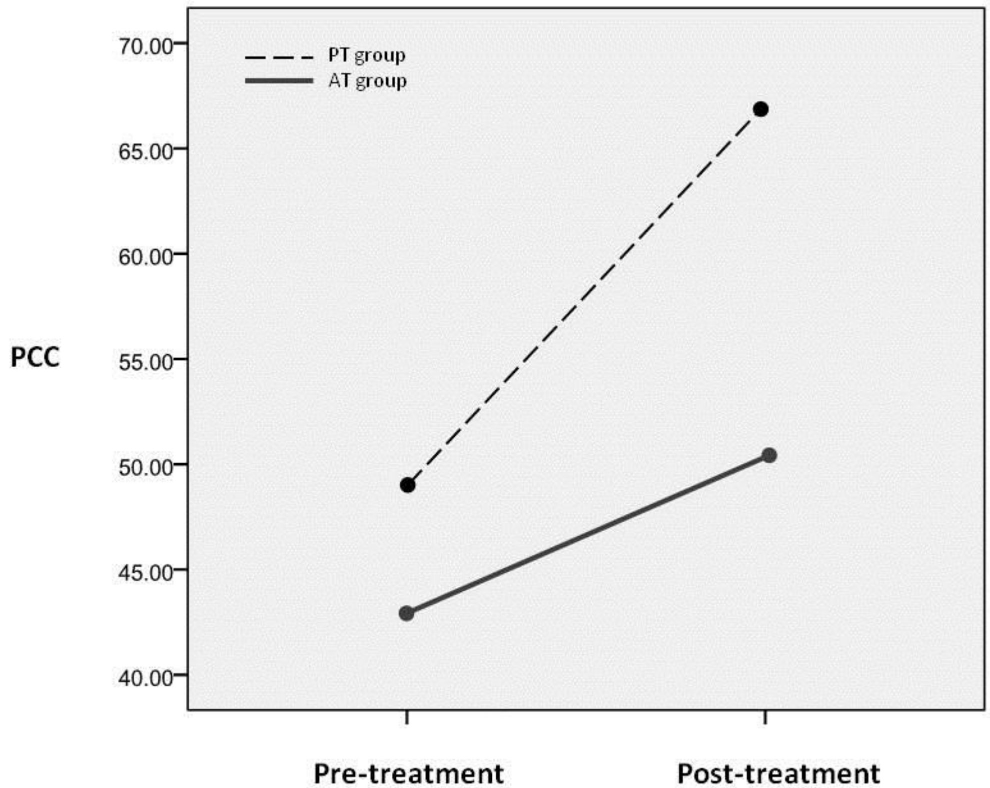

Figure 1. PCC scores at pre-treatment and post-treatment for PT and AT groups.

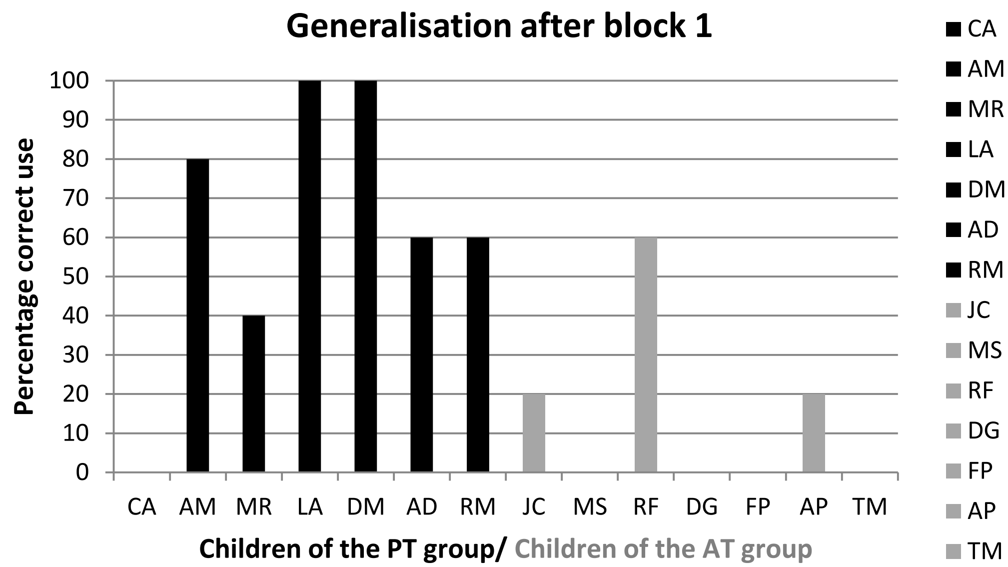

Figure 2. Generalisation to non-intervention words after block 1 (the percentage corresponds to the number of words where the target was correctly produced).

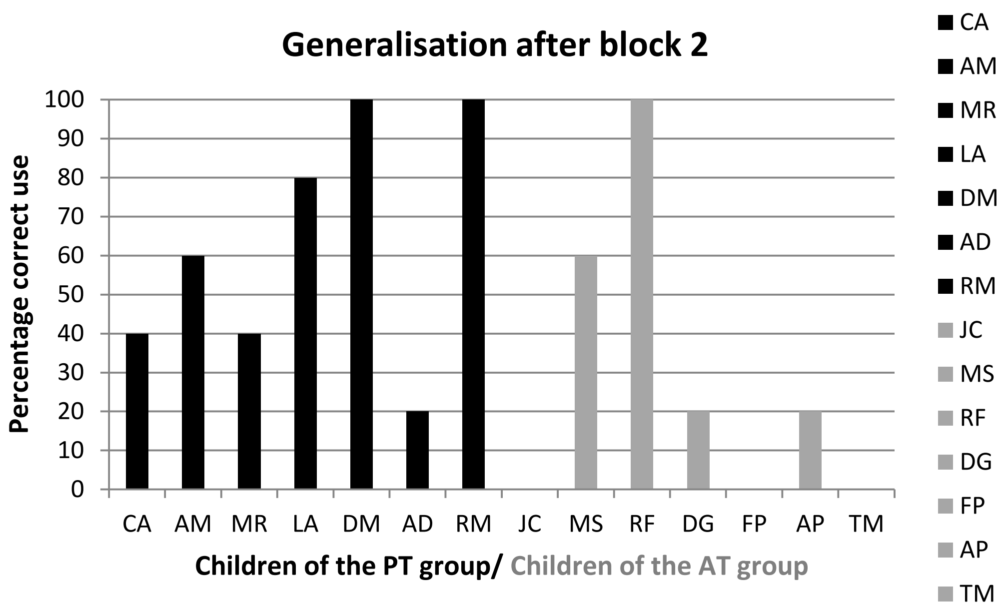

Figure 3. Generalisation to non-intervention words after block 2 (the percentage corresponds to the number of words where the target was correctly produced).

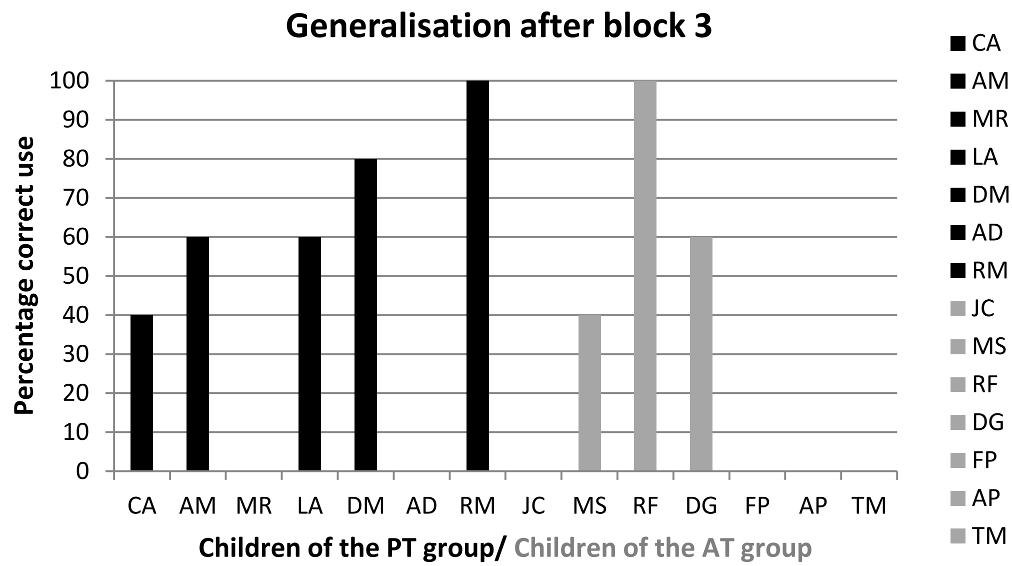

Figure 4. Generalisation to non-intervention words after block 3 (the percentage corresponds to the number of words where the target was correctly produced).