Ingressive speech errors: a service evaluation of speech sound therapy for a child aged 4;6.

Abstract

Background: A pattern of ingressive substitutions for word-final sibilants can be identified in a small number of cases in child speech disorder, with growing evidence suggesting it is a phonological difficulty, despite the unusual surface form. Phonological difficulty implies a problem with the cognitive process of organising speech in to sound contrasts.

Aims: To evaluate phonological therapy approaches in the remediation of non-pulmonic speech errors. Thus, adding to evidence concerning the nature of ingressive substitutions and their remediation, whilst highlighting their occurrence within child speech disorder population for practising and training Speech and Language Therapists (SLTs).

Methods & Procedures: Child KO, a boy aged 4;6, was identified through a screening of speech, language and communication needs at his school. Word-final, non-pulmonic-egressive substitutes for fricatives and plosives were identified using the Diagnostic Evaluation of Articulation and Phonology (DEAP). Treatment took place in five, weekly school-based sessions with a care-giver present, and targeted two phonemes /f/ and /ʃ/ in word-final position. Word-final /s/ was monitored throughout to capture any change in other word-final fricatives. Phonemes /g/ and /p/ were used as controls, as no change was expected in word-final plosives as a result of therapy targeting fricatives. Production of single-words in the DEAP, pre and post therapy were transcribed by two independent therapists, (transcription agreement was 86.6% (pre) and 83.7% (post), with all 140 consonants within the DEAP transcribed), and change in consonants correct was analysed using a Wilcoxon test. Picture description tasks and telling of familiar stories, were videoed post therapy to analyse use of word-final fricative egression in connected speech.

Outcome & results: Percentage consonants correct in single words post-treatment was significantly higher than pre-treatment at single-word level. Generalisation of target fricatives into connected speech, and modest generalisation of non-target phonemes occurred.

Conclusions & Implications: Although ingressive speech sounds are largely absent in the sound system of English, they do occur as speech sound errors in child speech disorder and respond to phonological therapy within the context of home and school environment. Therefore, training in the phonetic identification of speech sounds outside the system of English is essential. Additionally, non-lexical factors associated with ingression also influence the child's intelligibility and should be explored further in future research.

Keywords: child speech disorder, ingressive fricatives, non-pulmonic-egressive, phonology, evidence-based practice.

What this paper adds?

What is already known on the subject?

Research into non-pulmonic-egressive speech within child speech disorder is limited. However, ingressive substitutes for English sibilants have been identified and are considered to arise from a phonological difficulty.

What this paper adds?

This study widens the evidence-base for the remediation of ingressive speech errors, and raises awareness of their occurrence for training and practising SLTs.

Introduction

Twenty-nine percent of children presenting to Speech and Language Therapy services in the UK have speech difficulties, and the incidence of child speech disorder stands at 6.4% in otherwise typically developing children (Broomfield and Dodd, 2004). Children's speech sound disorders encompass various sub-types, and terminology varies throughout the literature. However, it is particularly important to distinguish between difficulties with articulation or phonology, as deficits in one or other of these areas affects intervention approach.

A phonological difficulty implies that the deficit lies in the child's acquisition and use of the rules of phonological contrast in their language, e.g. voiced and voiceless contrasts convey meaning; cu**p** vs cu**b**. This signifies a difficulty at the *phonemic* level which concerns the cognitive process of organising speech sounds into a system of sound contrasts (Bowen, 2011). An articulation difficulty implies that the deficit lies in the child's ability to execute their phonoarticulatory musculature in order to produce the correct phone or word: a difficulty at the *phonetic* level which concerns the motor act of producing vowels and consonants (Bowen, 2011). A child with an articulation difficulty may not be able to physically produce the voiced bilabial plosive /b/ and consistently uses [p] in its place, /kʌb/ said as [kʌp] and /bɪn/ said as [pɪn]. A child with a phonological difficulty may be able to physical produce both /p/ and /b/ but a difficulty in organising contrasts means they produce both /kʌp/ and /kʌb/ as [kʌp]. Thus distinguishing between articulation and phonological disorder at assessment is important as research has shown that intervention approaches need to target the specific level of deficit if they are to be successful (Dodd and Bradford, 2000). Specifically, children whose speech errors are characterized by the consistent use of non-developmental phonological rules respond best to therapy that targets reorganization of phonological knowledge rather than therapy that focuses on the articulatory aspects of speech production. Thus therapy approaches such as Metaphon which target metalinguistic awareness would be suited to a phonological difficulty, whilst PROMPT which targets appropriate movement of articulators may be suited to an articulatory difficulty: it is unlikely that a therapy method which focusses on the motoric production of speech sounds will impact on a child who is phonologically disordered (see Dodd and Bradford, 2000 for a comparison of therapy approaches).

Children with speech disorder may produce a variety of sound errors that are not present in the ambient, adult, phonological system. For example, Ball and Muller (2007) note unusual cases of pulmonic egressive targets, being substituted by pulmonic ingressive sounds, clicks, ejectives and implosives (Geirut and Champion, 2000; Heselwood, 1997; Chin, 2002; Shahin, 2006). Ball and Muller (2007) conducted a review of non-pulmonic-egressive speech in clinical data and note the errors have received little attention in the research and can be overlooked in the training of SLTs which in some instances, is virtually restricted to the sound system of English. SLTs should be aware of the occurrence of ingressive speech (both non-pulmonic and pulmonic), as instances have been reported across broad clinical populations: dysfluency, hearing impairment, cochlear implant users, cleft palate, velopharyngeal incompetence, Down's syndrome, and child speech disorder (Ball and Muller, 2007).

Given that there are no published figures pertaining to the incidence of ingressive speech errors, it may be postulated that their occurrence is rare. Baker and McCloed's (2011) review of evidence-based practice for speech sound disorders highlights the need for large scale studies in disorders that consistently present to clinicians. However, information from detailed case studies is helpful in directing intervention ideas for children with unusual clinical presentations (Baker and McCloed, 2011). In unusual presentations, large studies are implausible and there is an important role for collecting data through single-case studies to widen the evidence base. Clinicians are thus encouraged to report clinical cases of ingressive speech errors, and indeed other uncommon speech difficulties, in order to promote evidence based practice for the profession as a whole.

Perhaps the most unusual occurrence of ingressive speech errors exists within the child speech disorder population, as typically no other sensory, cognitive or physical impairment can be implicated as a causal factor. Nevertheless, a seemingly well-defined pattern of ingressive substitutes for English sibilants has been noted in reported cases of child speech disorder (Grunwell, 1981; Ingram and Terselic, 1983; Bedore, Leonard and Gandour, 1994; Geirut and Champion, 2000). Grunwell (1981) cites a child, who replaced all word-final sibilants with an ingressive voiceless lateral fricative [ɬ↓]. For example, /bʌs/ realised as [bʌɬ↓]. Ingram and Terselic (1983) describe child E, aged 4, who did not use fricatives word-initially, but used a word-final ingressive alveolar fricative [s↓] for word-final sibilants. Geirut and Champion (2000) report child IJ, aged 4;5, who omitted word-initial sibilants, whilst word-final sibilants were realised as a voiceless ingressive fricative with no identifiable, oral place of articulation [h↓]. For example, /zɛbɹə/ as [ibwə], /noʊz/ as [noʊh↓]. Notably, in all cases of pulmonic ingressive fricatives, there was a priority for post-vocalic or word-final positioning, i.e. there is no documented occurrence of word-initial ingressive fricatives. This preference for position indicates a phonological, rather

than articulation difficulty, as difficulties with motor planning and execution would be expected to surface in any word position.

Sibilants are again noted by Bedore et al (1994) who describe child C, aged 4, making context-free ingressive *clicks* as substitutes for English sibilants in all positions. Sibilants were substituted by a voiceless dental click [ǀ]. For example, /ʃu/ as [ǀu] and /dɪʃ/ as [dɪǀ]. Clicks differ from ingressive fricatives, in that they use a velaric, rather than pulmonic airstream. However, in all cases (Grunwell, 1981; Ingram and Terselic, 1983; Bedore, Leonard and Gandour, 1994; Geirut and Champion, 2000), only sibilants were indicated as the ambient target for ingressive substitutions.

In cases of context sensitive substitutions (Grunwell, 1981; Ingram and Terselic, 1983; Geirut and Champion, 2000), it could be postulated that syllable-final ingressive fricatives are allophonic realisations of English sibilants for the child in question. Indeed, Geirut and Champion (2000) speculate that IJ maintained underlying phonological representations for the category of sibilants whilst egressive and ingressive outputs were derived by allophonic rule (Geirut and Champion, 2000, p. 611). For example: underlying representation of /s/ is egressive, but allophonic derivation omits [s] word initially, and surfaces as [h↓] post-vocalically (Geirut and Champion, 2000). Bedore et al (1994) argue that C, who made context free errors, did not have sibilants in her phonetic output repertoire but her underlying phonological representations of sibilants remained adult-like. This was demonstrated by rapid, 'across-the-board-change' that the authors conclude could not have occurred if C did not already have the underlying representations to match the forms (Bedore, Leonard and Gandour, 1994, p. 292). Such conclusions are a positive predictor in the remediation of ingressive substitutions as they implicate a linguistic competence and ambient phonological representation whose atypical surface forms may be receptive to therapy.

Nevertheless, not all cases emulated Bedore et al's (1994) success. Ingram and Terselic (1983) comment that child E, was 'very resistant to changing his ingressive "s" and showed little progress with it over the first five months' (Ingram and Terselic, 1983, p. 49). However, the authors note that this may be due to the fact that [s↓] was a preferred sound for E, in that it was the most frequently used final sound in E's phonetic repertoire; thus it was the *preference* rather than the ingression that was resistant to change. Similarly, Geirut and Champion's (2000) child IJ showed a limited improvement, with treated sound /s/ being produced with 29% accuracy post-treatment and untreated sibilants not exceeding 18% accuracy. However, IJ was able to produce /s/ with 89% accuracy in the treated non-word stimuli by the final session (Geirut and Champion, 2000). Potentially, IJ's ingressive pattern was malleable to change, but he had difficulty generalising his learning from non-words in clinic to real words. An additional explanation for differences between the cases

might be that Bedore et al (1997) used real words with target /s/ to imitate and practise, which facilitated generalisation. Nevertheless, Bedore et al (1997) conclude that in C's case, intervention played a narrow role: C was already stimulable on several sibilant sounds at the outset of the study. Furthermore, she began using these sounds correctly in spontaneous speech after only a few days of treatment on just one of these sounds. The authors conclude that 'traditional instruction and practice components of the intervention process were seemingly not operative' (Bedore et al, 1997, p.292). Thus, although change in C's output occurred, it cannot readily be attributed to therapy.

A tentative look at the current evidence suggests that the unusual use of ingressive airflow at the phonetic level may be the result of erroneous allophonic rules at the phonemic level. This is of utmost importance as it is now recognised that clearly distinguishing between an articulation or phonological difficulty at the assessment stage is crucial, as it affects intervention approach (see Dodd, 2005; Bowen 2001). A difficulty at the phonemic rather than phonetic level suggests that phonological therapy approaches may be successful. Previous difficulties in remediation may have arisen from confounding factors such as preferred sounds (Ingram and Terselic, 1983), or overcoming phonemic splits in complementary distribution (see Geirut and Champion, 2000, p. 612-613 for full discussion). There are various interventions that target phonological disorders (see What Works?, Communication Trust, 2014; Baker and McLeod, 2011, for a review of approaches). However, typical service provision components are included in therapeutic management in varying degrees according to individual differences in the child with phonological disability and his or her family: (1) family support network; (2) metalinguistic tasks, focusing on aspects of linguistic awareness and phonetic and phonological processing; (3) traditional phonetic production procedures; (4) multiple exemplar techniques, including minimal contrast and auditory bombardment activities; and (5) homework activities, incorporating (1)–(4) (Bowen and Cupples, 1998. p. 32). This multi-faceted approach has *functional communication* as its guiding principle*.* Functional communication refers to the child's intelligibility in everyday speech both at home and school (Dodd, 2005). The occurrence of non-pulmonic-egressive speech sounds in a speaker of English is likely to have a marked impact on intelligibility due to absence of these sounds in English phonology. Therefore, a reduction in the use of ingression would increase intelligibility. If the reduction was sustained in the home and school environment, improvements in functional communication would be made: improvements in functional communication can be achieved through the generalisation of therapy gains into non-clinical environments, thus the participation of parents and teaching staff in essential (Dodd, 2005. p. 131).

The current study aims to apply robust research techniques within the remit of typical service provision in a UK service: evaluating the remediation of non-pulmonic speech errors in a way that SLTs can realistically replicate in clinical practice. The

study aims to add to evidence concerning the nature of ingressive substitutions and furthers the aforementioned studies (Grunwell, 1981; Ingram and Terselic, 1983; Bedore, Leonard and Gandour, 1994; Geirut and Champion, 2000) by highlighting new patterns of ingressive substitutions that, for one child, implicates other word-final fricatives as well as sibilants, and also word-final plosives.

Method

Participant

Child KO, a boy aged 4;6, was identified through a screening of speech, language and communication needs at his primary school. KO had age appropriate receptive and expressive language, and normal hearing (confirmed by an audiologist). KO was a monolingual speaker of English and had no history of ear infections or frequent colds, as determined by parental report. Although healthy at the time of assessment, KO had open heart surgery at 11 days old and was tube fed for the first four weeks of his life. This may have impacted on KO's early suck swallow patterns, and certain research suggests that successful feeding and swallowing is a predictor for normal communication (Cichero & Murdoch, 2006)**.** This is because suck, feed and speech-language production areas are encoded and modified by overlapping networks of cortical, sub-cortical and brainstem regions in the brain (Barlow & Poore, 2009.) However, KO's mother reported no subsequent feeding difficulties, thus it may be supposed that he quickly developed typical suck swallow patterns. His mother, sister and KO were born with a tongue-tie, which was cut at birth. Nevertheless, his oro-motor examination was normal and he had full range of tongue movement. KO had received no previous speech and language therapy and there was no history of speech and language difficulties in the family. Parental consent to partake in the study was gained with the stipulation that therapy input would be the same if even if they chose to not take part. Ethical approval was gained from City University London, School of Health Sciences Ethics Committee.

Design

Table 1. Therapy design

Phase A (baseline)	• Initial assessment: articulation screener; BPVSIII; RAPT. 4 week break with no treatment • Session 1: Pre-treatment measures: DEAP videoed; control phoneme probes administered
Phase B (treatment)	• Session 2: Therapy targeting metalinguistic concept of 'in' vs 'out' • Session 3: Therapy targeting /f/ and /ʃ/ at VC level

	• Session 4: Therapy targeting word-final /f/ and /ʃ/ at single-word CVC level; control phoneme probes administered. • Session 5: Therapy targeting word-final /f/ and /ʃ/ at single-word CVC in modelled carrier sentence. • Session 6: Therapy targeting word-final /f/ and /ʃ/ single-word CVC within spontaneous connected speech, e.g. picture description task.
Follow up	3 week break with no treatment • Session 7: Post-treatment measures: DEAP videoed; control phoneme probes administered; connected speech tasks videoed.

The study followed a single-subject AB design with control phoneme (McReynolds and Kearns, 1983). The baseline period (phase A), took place in the period allowed for by the service provision, i.e. four weeks between initial speech and language screen and pre-treatment measures. Treatment phase B took place over 5 weeks: one weekly session at school with therapist and care-giver, lasting 45 minutes; daily home practice activities lasting no more than 10 minutes. Geirut and Champion (2000) postulated that using more than one target phoneme in therapy may trigger the fine-grained distinctions required for target-appropriate segmental productions. KO's most widespread speech error was using ingressive fricatives and affricates word-finally: full assessment analysis will be presented later in Outcome & Results. Therefore, two target fricatives were chosen for treatment; /f/ and /ʃ/. During treatment phase B, these two phonemes were treated and a three untreated control phonemes /g/ /p/ and /s/, were monitored: single-word probes containing untreated phonemes were presented in sessions 1, 4 and 7. Service provision allowed for one follow-up session approximately one month after the completion of therapy to ensure progress is maintained and reassess and/or refer to other services if necessary: follow-up was conducted three weeks after the completion of therapy.

Pre-treatment measures

Standardised assessments were used at initial screening to assess receptive and expressive language and speech sound production: British Picture Vocabulary Scales III (BPVSIII; Dunn et al, 2009); Renfrew Action Picture Test (RAPT; Renfrew, 2003); informal articulation screen. Four weeks later, KO's speech and oromotor function was assessed using the Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd, 2002). The phonology assessment (DEAP; Dodd, 2002) which includes single-word and connected speech tasks was video recorded as a pre and post treatment measure using a High Definition camera: Philips CAM110RD Full HD 1080p. Two trained listeners independently transcribed the footage from the DEAP assessments using narrow notation of the IPA and transcription agreement was determined to be 86.6% (pre) and 83.7% (post) with all possible 140 consonants within the DEAP transcribed. Acceptable allophonic realisations were counted as correct if deemed appropriate for accent or context (see appendix for included

allophones). A phonemic inventory and error pattern analysis were used to explore distribution and substitute mapping.

Therapy: phase B (see table 1)

Therapy sessions took place in a quiet room within KO's primary school with his mother and the therapist present. A member of school-staff was unable to attend but the therapist liaised with KO's class teacher and classroom assistant after every session ensuring therapy goals were reinforced during classroom phonics sessions. KO's mother reported that KO's sister, aged 8, helped with home practice activities, as they played the games as a family. As she attended the same primary school, KO's sister was able to attend some therapy sessions and was present for sessions three, four and five within phase B.

Session 1

Session 1 targeted the concept of 'in' and 'out' sounds. This was demonstrated with items such as party-blowers, i.e. *nothing happens* when you breathe in but it has the desired sound when you blow out. This concept was then discussed using voiceless fricatives. Items such as feathers were used in front of the mouth to show the direction of air needed to make [f] [s] and [ʃ]. These tasks were repeated without the use of feathers to help KO hear the difference between ingressive and egressive airflow.

Session 2 to 6

When KO understood the concept of 'out' sounds, therapy required him to produce out sounds accurately in stages: VC in isolation; single word CVC; single word within a carrier sentence modelled within a card game, e.g. 'have you got a *wolf*?'; one or more target words within a spontaneous sentence, e.g. a picture description. Specific materials were created on Boardmaker ® for use in therapy, e.g. bingo boards and board games containing 22 CVC and CVCVC picture cards with word-final fricatives /f/ and /ʃ/. Various games (see Appendix for an example) were used to give KO intensive practice of the egressive word-final targets. During the game the therapist would ask KO's mother to note the specific feedback and praise being given on KO's performance. The game would be played again and KO's mother would give feedback and praise as required. The same game was then given as a home practice activity to be played once a day, as well as a written reminder of the game's rules and examples of praise or feedback that could be given. e.g. 'that was a clear out sound' or 'that sounded like an in sound to me, let's try it again'. When KO and his mother were familiar with more games, they played a variety throughout the week to keep KO motivated.

KO was required to produce an egressive fricative in the *target word* with 80% accuracy before moving on to the next stage. N.B. an egressive fricative was not required in the 'have' of 'have you got a wolf?': [haf:↓ ju: gɒl ə wʊlf:] was accepted.

Post-treatment measures

After a 3-week break with no treatment, the DEAP assessment was administered again, in order to collect data on change in single word production. Connected speech tasks within the DEAP were also administered, as well as informal connected speech tasks: eight pictures containing treated phonemes were used to elicit spontaneous speech, and KO was asked to retell a familiar story 'The big bad wolf and the three little pigs'. All connected speech tasks were videoed and transcribed by two trained independent SLTs who analysed what percentage of all possible word-final fricatives (treated and untreated) were produced egressively (59 word-final fricatives were identified in total).

Outcome & Results

Single word production

A s described above, a phonology assessment (DEAP; Dodd, 2002) was conducted pre-treatment in session 1 and post-treatment in session 7, to assess overall change in KO's consonant production at single word level.

Pre-treatment

Table 2: Pre-treatment error analysis

Error Pattern	Realisation
Developmental error pattern Fronting of velars Voicing Fronting + voicing Devoicing	 /k/ → [t] /t/ →[d] /k/ → [d] /v/ →[f]
Atypical error pattern (all word-final) Ejectives Clicks Ingressive fricatives	 /k/ /g/ → [k'] /p/ → [ʘ] /t/ → [ǀ] /v/ /θ/ /f/ → [f:↓] /s/ /z/→ [s:↓] /ʃ/ /tʃ/ /dʒ/→ [ɬ:↓]

Before treatment KO's atypical errors were context sensitive (see table 3 for pre-treatment word-initial and word-final phonetic inventory). Although present word-initially, KO substituted voiced and voiceless bilabial and alveolar plosives with a click word-finally. The clicks retained place of articulation in that they were bilabial and dental/alveolar respectively. Thus, although using an ingressive airstream, these realisations mirrored the visual qualities of the target plosive.

Table 3: Pre-treatment phonetic inventory

Word-initial						*Word-final*					
p		t		k		ʘ		ǀ		kʼ	
b		d		g							
	f	s	ɕ		h		fː↓	sː↓	ɬː↓	ʃː↓	
		ʑ									
m		n				m		n			
		ɹ		w						w	

KO used a voiced and voiceless velar plosive word-initially, but replaced both with the voiceless velar ejective plosive word-finally. Use of ejectives has been noted in non-clinical speech as a realisation of word-final plosives followed by a voiced sound such as a vowel. For example, word-final /k/ in Scottish English (McCarthy and Stuart-Smith, 2013). Thus, the use of word-final ejectives did not affect KO's intelligibility.

KO's use of word-initial fricatives was restricted to [f] and [s] only with /v θ/ realised as [f]; /ð/ omitted; and /z ʃ/ palatalised as [ʑ] and [ɕ] respectively. The most striking element of KO's speech was his substitution of fricatives and affricates with lengthy ingressive fricatives in word-final position. Although unclear, an element of placement appeared to be preserved as the ingressive fricatives were perceptually different to the trained listener: /f v θ/ realised as [fː↓]; /s z/ realised as [sː↓]; /ʃ tʃ dʒ/ realised as [ɬː↓]. Nevertheless, there was a homogeneous sound quality to all word-final fricatives and affricates in everyday speech, which both KO's teacher and therapist felt had a marked effect on the KO's intelligibility. Furthermore, it was observed that word-final frication decreased KO's intelligibility due to the timing

required to reverse airflow mid-word, having the perceptual effect of adding a syllable, e.g. /fɪʃ/ → [fɪ.ʃ↓]. Therefore, ingressive word-final fricatives were targeted in therapy as a reduction in ingression would have the largest impact on functional communication.

Pre-treatment KO produced 56.6% of consonants correctly (PCC standard score 3, 1st percentile).

Post-treatment

Post treatment, KO produced 80.6% of consonants correctly (PCC standard score 5, 5th percentile). Errors that remained included gliding (age-appropriate) devoicing, ejectives and clicks, as seen in table 4.

Table 4: Post-treatment error analysis

Error Pattern	Realisation
Developmental error pattern Devoicing	/z/ →[s] N.B. word final /z/ now [s] rather than ingressive.
Atypical error pattern (all word-final) Ejectives Clicks	/k/ /g/ → [k’] N.B. /g/ produced as [g] on one occasion /t/ [t’] N.B. /t/ was previously dental click. /p/ → [ʘ]

Table 5: Post-treatment phonetic inventory

ʘ	t’	k’
b’	d	k’ g
f	s ʃ	

Word-initial							*Word-final*	
p			t		k		m	n
b			d		g			
	f		s	ɕ		h		l
	v	ð	z					
m			n					
			ɹ		w			
			l					

Change in single-word production pre-to post-treatment

In order to assess the significance of KO's overall improved consonant production, a Wilcoxon analysis was carried out on the consonants produced correctly in all fifty word items of the pre and post treatment DEAP. For example, at time 1 (pre-treatment DEAP) KO produced 3 consonants correct in item 18, /splaʃ/ → [splaʃːˌ↓]; at time 2 (post-treatment DEAP) KO produced 4 consonants correct in item 18, /splaʃ/ → [splaʃː]. Change in correct consonant production from time 1, to time 2, for 50 identical words, was thereby assessed for significance using Wilcoxon analysis.

KO's consonant correct score pre-treatment (median=1, IQR= 1-2) was significantly lower than his post-treatment score (median= 2.5, IQR= 2-3, W= 0.0, $p<0.01$).

In addition, word-final fricatives and affricates within the phonology assessment (DEAP; Dodd, 2002) were analysed pre and post therapy in order to assess change in egressive production specifically. Thirteen of the fifty words in the phonology assessment (DEAP; Dodd, 2002) contain word-final fricatives or affricates. Pre-treatment 100% were produced with ingressive airflow. Despite treating only /f/ and /ʃ/, post-treatment, 100% of all fricatives and affricates were produced with egressive airflow, suggesting widespread generalisation of egressive airflow to untreated phonemes. Nevertheless, although now egressive, not all consonants were produced correctly and in most cases the frication remained lengthy, as shown in table 6.

Table 6: Post-treatment realisations of word-final fricatives and affricates

Target sound	Realisation
/f/ /v/	[fː] [f]
/s/ /z/	[sː] [s]
/ʃ/	[ʃː]
/tʃ/	[ʃː]
/dʒ/	[ʑ]

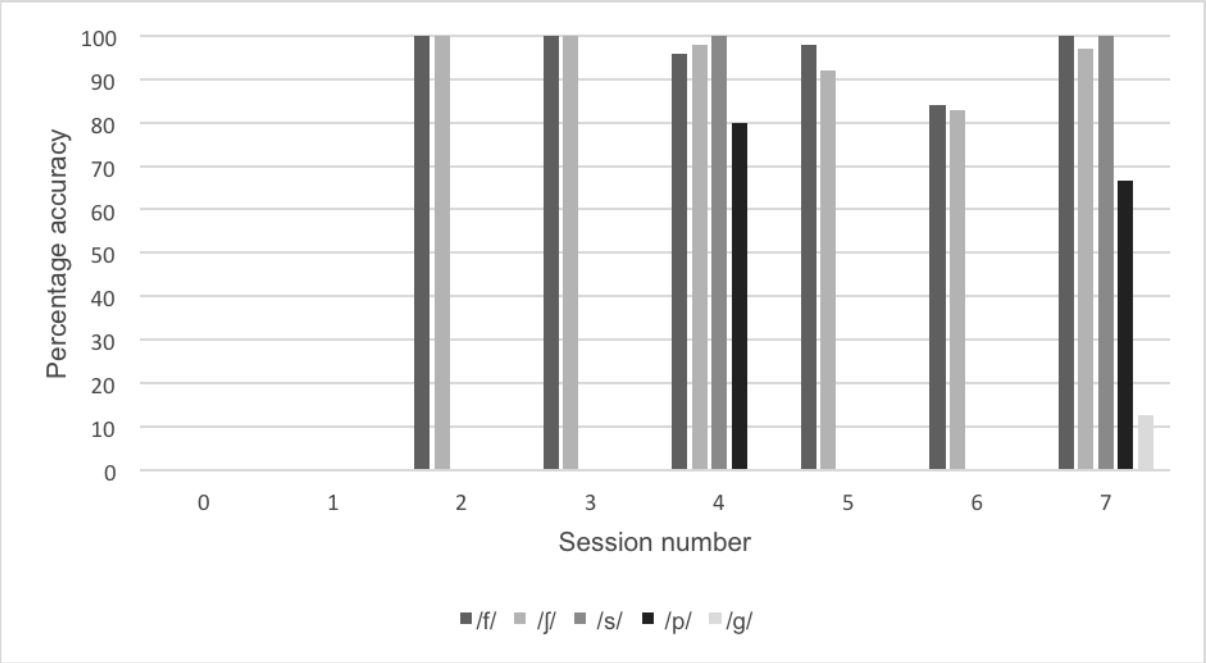

Figure 1. Accuracy in word-final production of treated and control phonemes at baseline (0-1), therapy (2-6) and follow-up (7) at single-word level.

Control phonemes

Phonemes /g/ and /p/ were used as controls, as no change was expected in the production of word-final plosives as a result of therapy which targeted fricatives. However, an unexpected change in word final plosives was observed over the course of therapy (see figure 1). In session 4, and in the post-treatment DEAP, change in production of /p/ at single-word level was seen: of 6 possible targets 2 were produced as [Θ], 4 as [p'] suggesting that egressive airflow may be beginning to generalise to plosives. Similarly, word-final /t/ was produced as [t'] in the post-treatment DEAP where previously it was produced as [l]. No change was noted in the production of word-final /k/ which continued to be produced as [k'] in all cases. However, figure 1 shows that in session 7, KO produced one of eight possible word-

final /g/ appropriately [ɛg], the remaining 7 were produced as [k'] as expected. (See table 5 for post-treatment phonetic inventory).

Connected speech

KO was able to use word-final /f/ and /ʃ/ into connected speech by week 6 of phase B and maintained this three weeks later at follow-up.

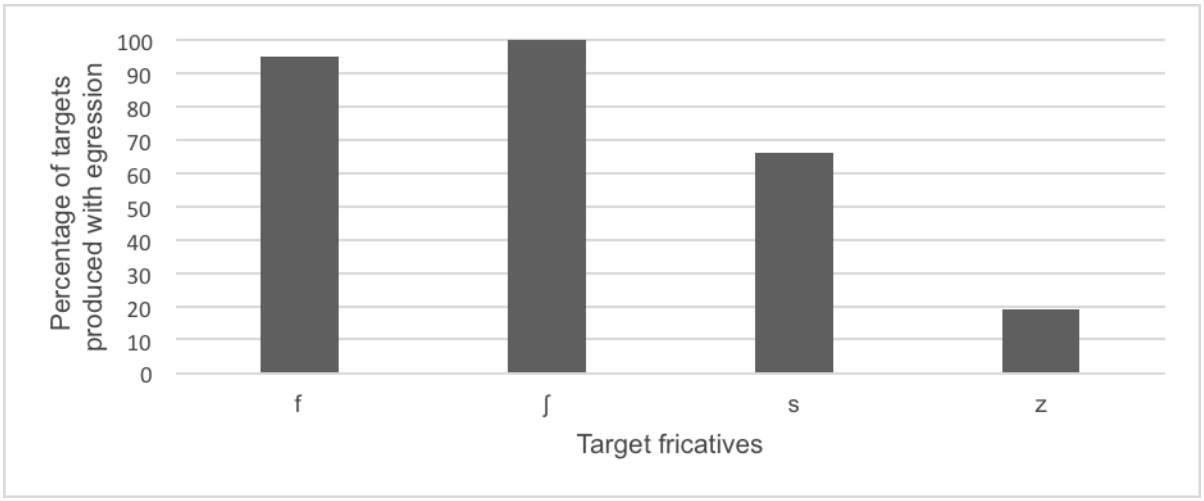

Figure 2. Post-treatment egressive production of treated and untreated fricatives in connected speech

KO used a total of 59 words containing word-final fricatives in post-therapy connected speech tasks: connected speech DEAP, picture description and telling of a familiar story. As well as targeted /f/ and /ʃ/, this included /s/ /z/ /v/ and /θ/ (/v θ/ and are not included in figure 2 as only one example of each was recorded). KO produced 72% of possible word-final fricatives with egressive airflow. Although not produced correctly, e.g. /z/ → [sː] targets were largely produced egressively. Figure 2 shows modest generalisation to untreated /s/ and minimal generalisation to untreated /z/: 81% of all *ingressive* airflow occurred in function words ending in /z/, particularly /ɪz/, e.g. [ə ɕɛfː ɪsː↓ gənə kʌtʼ ə fɪʃː].

Discussion

This single-case study evaluated traditional phonological therapy approaches in the remediation of the unusual use of non-pulmonic speech errors in child speech disorder; building on the findings of previous research in this area (Bedore, Leonard and Gandour, 1994; Geirut and Champion, 2000). Like IJ (Geirut and Champion,

2000), KO's errors were context sensitive and potentially derived ingressive phonetic output from allophonic rule. For example, /f/ was realised as [f] word initially and [fːˈ] word finally. The shift in ingressive to egressive production of all word-final fricatives and affricates in the pre and post DEAP (DEAP; Dodd, 2002) shows a generalisation from treated phonemes /f/ and /ʃ/ to untreated fricatives and affricates at single-word level. Importantly, this suggests that teaching the concept of 'in' versus 'out' sounds had the desired affect at a metalinguistic level, i.e. egression is desirable for *all* speech sounds not just the target phonemes. KO responded well to 6 weeks of therapy with a phonological basis: change demonstrated beyond the target phonemes supports the argument for a phonological rather than articulatory difficulty in this case.

Single-word level: why was therapy successful?

A possible contribution to KO's swift response to therapy, is his preservation of placement in his pre-treatment ingressive errors. This contrasts with previous studies that have reported a uniform fricative substituting all sibilants, often with no identifiable place of articulation (Grunwell, 1981; Ingram and Terselic, 1983; Geirut and Champion, 2000). KO's more varied ingressive fricative use, may have simplified the process of change in KO's allophonic rule, as only direction of airstream needed to change whilst place and manner remained the same. Notably, only voiceless fricatives were targeted in therapy and although word-final fricatives and affricates were produced egressively post-treatment, they largely remained *voiceless,* e.g. /faɪv/ → [faɪfːˈ]. It may be that KO will need additional therapy to address voiceless and voiced contrasts. Potentially, children using uniform voiceless ingressive substitutions for a range of fricatives may need to address placement first, before progressing to the egressive target and voiced/voiceless contrasts.

Encouragingly, a change in ingressive to egressive production occurred in KO's word-final voiceless plosives, post-treatment, which may signal a process of change in KO's linguistic system. Nevertheless, KO's egressive realisation retains a perceptually emphatic plosion for [tʼ] and [pʼ] that would not typically be expected in word-final English /p/ unless followed by a pause. Remember that this was already true for /k/ which was produced [kʼ] word-finally pre and post treatment. Notably, data is limited and there is only one example of each word to evidence this change at single-word level. Nevertheless, it is interesting to note that KO's linguistic system may be reorganising all word-final, ingressive derivations to egressive allophones: although word-final allophones remain emphatic [pʼtʼkʼ]. It could be that KO's allophonic rule requires word-final realisations to be perceptually stronger than their word-initial counterparts, perhaps as a way of marking word boundaries. Pre-treatment, this was achieved with velaric ingressive clicks or ejectives for plosives,

and lengthy pulmonic ingression for fricatives: ingressive or velaric realisations were utilised as a means of increasing acoustic force over their pulmonic- egressive word-initial counterparts. Although therapy remediated the ingression, KO's allophonic rule still demands word-final emphasis through use of ejectives and lengthened voiceless fricatives.

Having a parent as an active agent of therapy was undoubtedly a contributing factor to the success of the intervention and why he achieved each of his weekly therapy goals: achieving 80% accuracy at the each level, e.g.VC then CVC etc. Furthermore, using the child's school rather than clinic as a setting for therapy allowed regular and positive communication between teaching staff, parents and therapist who were all aware of KO's weekly therapy goals and reinforced them outside of the session. The majority of KO's learning took place outside of the therapy session, as Dodd (2006) notes, time spent in therapy sessions is limited compared to time spent at school and home therefore active participation of teaching staff and parents is essential in generalisation of therapy (Dodd, 2006, p. 131).

Connected speech: lexical and non-lexical factors

Dodd (2006) asserts that therapy cannot be evaluated solely on the test/re-test of a standardised assessment: an appropriate language sample of spontaneous speech provides information on functional communication, which is ultimately the clinician's target. Thus, the connected speech data (figure 2) is a more valid outcome of therapeutic success. KO was able to generalise use of word-final /f/ and /ʃ/ into connected speech by week 6 of phase B and maintained this generalisation three weeks later at follow-up. However, generalisation of /s/ and /z/ was more modest than single-word data suggests. This is particularly true of word-final /z/ which was produced egressively in less than 20% of targets. Interestingly, this finding was largely due to function words remaining ingressive /ɪz/ → [ɪsːˈ↓]. As function words occur so frequently this pattern had a large impact on the perceived fluency of KO's speech.

Of further interest is the non-lexical impact of ingression on connected speech. KO's errors retained elements of placement and were arguably contrastive, i.e. KO did not used ingression with identifiable place of articulation [hˈ↓], but [fːˈ↓] and [ʃːˈ↓] etc. However, it is not just lack of contrast that influences intelligibility: teaching staff described KO's speech as difficult to listen to because he sounded as if he was distressed or dissatisfied despite describing something he was pleased about. Thus, interpretation of KO's speech was affected by the difficulty listeners had in discerning his overall message; a message that was distorted at a lexical and non-lexical level.

For example, KO used clicks non-lexically in word searching: ‘he um...blowed it down’ [hiː əːm ǀ bləʊl ɪl daʊn]. Although not present in English phonology, clicks are known to occur in English conversation as a resource for making meaning (Ogden, 2013). Ogden (2013) argues that clicks have three distinct systems: marking incipient speakership, i.e. the transition from listener to incipient speaker; sequence management, as elements of processing or word search; and displaying a stance, conveying dissatisfaction, perhaps with something another person has said or (in the case of word search) with one’s own performance (Ogden, 2013). Furthermore, Eklund (2008) explores the function of pulmonic ingressive phonation and cites various examples of its use in creating meaning: expressing surprise, pain, or in moments of tension. These paralinguistic uses may have consequences for a child using ingressive clicks and fricatives in disordered phonology, as the listener may interpret non-verbal stance taking or emotion within the lexical content of speech, which is not intended.

When considering the high rate of ingression remaining in function words, mid-sentence post-treatment, one may surmise that although intelligibility of the *content* of the sentence is improved through increased accuracy of production of nouns, elements such as non-verbal stance taking may remain. It would be prudent for future studies to target function words as well as nouns in the remediation of word-final ingressive fricatives as they occur frequently in English, e.g. was, has, is, this, it’s. Establishing an egressive output would improve the intelligibility and fluency of spontaneous speech even if voicing was not achieved, i.e. /ɪz/ realised as [ɪs] rather than [ɪz] could be acceptable. Future studies may also benefit from the inclusion of intelligibility ratings from unfamiliar listeners and recording the listener’s opinion of the feelings/stance the child is conveying.

Outcome data for connected speech would be improved by the inclusion of pre and post treatment intelligibility ratings from a body of unfamiliar listeners. Although small in sample size, connected speech tasks of the DEAP (DEAP, Dodd, 2002) could be presented to unfamiliar listeners to provide some insight into changes in KO’s intelligibility. However, a more extensive pre-treatment, spontaneous speech sample could have been taken for comparison with the post-treatment data, e.g. the telling of a familiar story.

Conclusion & Implications

The current study has highlighted key concerns in the assessment and treatment of ingressive speech errors. Firstly, this case adds to the evidence suggesting a pattern of word-final fricative ingression is observable in child speech disorder (Grunwell,

1981; Ingram and Terselic, 1983; Geirut and Champion, 2000). Furthermore, word-final plosives may arise phonetically as ingressive clicks: clearly, training and practising SLTs need be aware of the existence of word-final ingression in child speech disorder. Therefore, training in the phonetic identification of speech sounds that lie outside of the natural system of English is essential in order to provide an accurate and detailed *narrow* notation of the IPA: without good phonetics there can be no reliable intervention plan (Ball et al, 2009). Additionally, SLTs should be aware of the non-lexical meaning that can be conveyed by ingressive speech errors, i.e. the listener may perceive distress or displeasure where none is intended. As well as increased intelligibility at the phonetic and therefore lexical semantic level, the clinician may wish to consider a decrease in misinterpreted non-lexical stance-taking as a target for children using ingressive phonation: both factors will affect the listener's interpretation of the child's message. Finally, although ingressive speech errors are perceptually unusual at the phonetic level, a small body of growing evidence suggests that it is a phonological difficulty, remediated by phonological-based intervention that emphasises generalisation of skills at home and school.

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Appendix A

Accepted allophones

Target phoneme	Accepted allophone
/θ/	[f] as in [tiːf]
/w/	[ʊ] as in [kʊin]
/k/	[k'] as in [dʌk']

/ʃ/	[ɕ] as in [ɕiːp]
/ð/	[v] as in [fɛvə]
/t/	[ʔ] [t’] as in [laɪʔhaʊs] [ɛləfənt’]
/z/	[ʑ] [s] as in [ʑɛbɹə] [sɪzəs]
/ŋ/	[n] as in [fɪʃɪn]

Example of therapy game: Stepping stones
Individual picture cards of target words were placed on 6 stepping stones along the floor, e.g. leaf, wish, roof, bush, hoof, and brush. KO had to produce each word 5 times with an egressive word-final fricative before he could jump to the next stone/word. If an ingressive sound was heard, KO fell into the water with the crocodiles and had to start from the beginning. Specific praise and feedback was given on KO’s productions.

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