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From hindsight to foresight: working around barriers to success in phonological intervention

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Abstract

A major goal of phonological intervention is to help bring a child's speech development to within normal range for his or her developmental stage. Reaching that goal may take longer than anticipated for some children. This paper illustrates an in-depth retrospective evaluation of assessment data from one child with a phonological impairment, who progressed slowly during intervention (Baker and McLeod, 2004). An alternative intervention plan is suggested that takes key factors from the assessment data into account, and utilizes a nonlinear phonological framework to set up the goal sequence. The insights gained from hindsight in this case may lead to foresight for other children's intervention programmes.

A major goal of phonological intervention is to help bring a child's speech development to within normal range for his or her developmental stage. Although that goal is often achieved (Gierut, 1998b), progress for some children may be slower than anticipated. Because slow progress in speech development can have other negative consequences, for example, for literacy (Bird et al., 1995) or social development (McLeod and Bleile, 2004), it is vital to find ways around barriers to

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success during phonological intervention. Identifying which client, therapist, and/or treatment variables are impeding progress, and finding ways to address them can be a challenging and time-consuming task. The speech and language therapist generally does not have time to manipulate discrete variables systematically to evaluate their impact. Rather, the therapist relies on clinical observations of a particular client and research evidence to modify a range of variables (Baker and McLeod, 2004). The current paper illustrates a process for examining client, therapist and treatment variables using data from one child, James, with a phonological impairment who progressed slowly during intervention (Baker and McLeod, 2004). This retrospective evaluation provides a framework for prospective intervention planning for other children. As Attanasio (1994) points out, intervention findings, negative or positive, provide therapists with clinically useful data. James’ case is no exception. With hindsight, key factors in James’ assessment data are identified that not only highlight variables that could have been modified during the intervention programme, but suggest how the treatment plan might have differed from the outset.

**James’ intervention study**

James was one of 12 participants in a phonological intervention study (Baker, 2000). At age 4;4, James’ phonological impairment was moderately severe, based on a measure of percent consonants correct (PCC) of 330 words during conversational speech. A phonological process analysis showed the following phonemic (segmental) processes (with selected examples):

1) velar fronting of /k/, /g/, /ŋ/  \[
\text{/}k/ > [t]\]
   car  /ka/ > [ta]
2) gliding of /r/ (sometimes /l/)  \[
\text{/}r/ (/l/) > [w]\]
   red  /red/ > [wed]
3) stopping of /ð/ and /θ/  \[
\text{/}ð/ > [d]\]
   that  /ðæt/ > [dæt]

In terms of the structure of words, there was reduction of initial /s/-clusters (100%) and /l/-, /w/-, and /r/- (approximant) clusters (43%), and a variety of other patterns.

1) cluster reduction: \[
\text{/sp/ > [p] spade /speɪd/ > [peɪd]; /st/ > [s] star /sta/ > [sa]; /bl/ > [b] blue /blu/ > [bu]\]
2) simplification of one element (40%): \[
\text{/pl/ > [pw] plate /pleɪt/ > [pwɛt]\}
3) affrication (10%): \[
\text{/kl/ > [tʃ] clock /klɒk/ > [tʃoʊt]\}
4) coalescence (merging of features from the two consonants into one, 7%): \[
\text{/kr/ > [f] Christmas /krɪsmɒs/ > [fɪntɔs]; /sp/ > [ʃ] spoon /spun/ > [ʃʌn]}\]

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Variability was within normal limits according to Dodd's (1995) variability index. (Additional detail on James' phonology at assessment is provided in Baker and McLeod, 2004)

Information was collected on a number of other abilities at assessment, including hearing status, oral motor skills, performance IQ and language. Test results are summarized in Table 1. Scores for all evaluations were within normal limits, with the exception of language production. Although scores were within normal limits on the Clinical Evaluation of Language Fundamentals – Preschool (Wiig et al., 1992), James' mean length of utterance in morphemes (MLUm) was 3.5, below the normal range (according to Miller, 1981). The MLUm was based on two 50-utterance pretreatment conversational speech samples. (The decision to use two different samples of 50 utterances was based on a recommendation by Paul, 1995). James had no history of otitis media with effusion. There were no symptoms consistent with developmental verbal dyspraxia, no apparent neurological or neuromotor abnormalities, no behavioural difficulties or known psychiatric disorder, and no prior intervention for speech or language difficulties. In terms of family history, James' two elder brothers had a history of communication impairment. One had a fluency disorder, and the other had a language impairment with a history of phonological impairment.

James' intervention programme began with /s/-clusters. These were selected in accordance with evidence that treatment of developmentally later phonological elements can result in the fastest gains in intervention (Gierut, 1998a). Word-initial /s/-clusters (/st, /sp/, /sn/) were selected over the more

<table>
<thead>
<tr>
<th>Test variable</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent consonants correct (PCC) during conversational speech</td>
<td>54.1</td>
</tr>
<tr>
<td>Percent consonants correct (PCC) during 200 single word sample</td>
<td>54.5</td>
</tr>
<tr>
<td>Receptive language score on CELF-P&lt;sup&gt;a&lt;/sup&gt;</td>
<td>98</td>
</tr>
<tr>
<td>Expressive language score on CELF-P</td>
<td>94</td>
</tr>
<tr>
<td>Peabody Picture Vocabulary Test – Revised (Dunn and Dunn, 1981)</td>
<td>94</td>
</tr>
<tr>
<td>MLUm&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.5</td>
</tr>
<tr>
<td>Performance IQ, based on WPPSI-R&lt;sup&gt;c&lt;/sup&gt;</td>
<td>113</td>
</tr>
<tr>
<td>Oral musculature and structure, based on Robbins and Klee (1987)</td>
<td>24</td>
</tr>
<tr>
<td>Oromotor: Movements in context, based on Ozanne (1992)</td>
<td>21</td>
</tr>
<tr>
<td>Oromotor: Sequenced oral-volitional movements, based on Ozanne (1992)</td>
<td>25</td>
</tr>
</tbody>
</table>

<sup>a</sup>Clinical Evaluation of Language Fundamentals – Preschool (Wiig et al., 1992).
<sup>b</sup>Mean length of utterance in morphemes (based on two 50-utterance pretreatment conversational speech samples, as recommended by Paul, 1995).
<sup>c</sup>Wechsler Preschool and Primary Scale of Intelligence – Revised, Australian edition (Wechsler, 1989).
advanced approximant clusters because all /s/-clusters were reduced. Treatment occurred at the Communication Disorders Treatment and Research Clinic at The University of Sydney twice a week for 45-minute individual treatment sessions with the first author, a speech and language therapist. Although phonological intervention programmes can successfully involve the family in home programming (Bowen and Cupples, 2004; Broen and Westman, 1990), this programme did not do so in the early stages. The reason for this was that James was part of a larger study on the efficacy of phonological intervention (Baker, 2000), in which a range of variables needed to be controlled. Parental input was one of these variables. Each session consisted of 100 trials of 10 contrasting minimal word pairs (with and without initial /s/-clusters) presented with an in-house multimedia computer programme developed by the first author. The treatment words focused on three initial /s/-clusters, /sn, st, sp/, and included snail/nail, spot/pot, spill/pill, stand/sand, snow/no, sneeze/knees, sting/sing, stick/sick, stay/say, and spin/pin. Remaining /s/-clusters /sk, sm, sl, sw/ were used to evaluate response generalization. In the computer programme, James was presented with a scene (for example, a park) in which the target words and minimal pair contrasting words were pictured. James could request that the therapist click on a particular object (for example, snail) or request a particular action (for example, spin). Those objects and actions that began with a consonant cluster were animated and had an accompanying sound. The contrasting words with initial singleton consonants were not animated, and were therefore assumed to be less appealing.

Intervention progressed from single-word production trials to sentence trials, first with instructional feedback, and then without feedback. The instructional feedback consisted of both conceptually based feedback and phonetic cues; the first 50 trials had conceptual feedback only, and the next 50 trials, both conceptual and phonetic feedback. Conceptual feedback focused on the meaning of the utterance; for example, if James said nail for snail, the therapist might say ‘Do you mean nail or snail, I’m not sure what you mean, tell me again’. Phonetic cues included statements such as ‘You forgot the long [s] sound on that word. Say it again, this time use the [s] sound at the beginning’. If James produced a correct response, he was given conceptually based positive feedback, for example, ‘Oh, the snail, I understand you now. Let’s move the snail’. The aim of the conceptually based feedback was to highlight to James the need to produce a contrast between singletons and consonant clusters, in order to be understood.

Progress was dependent on James achieving 90% correct production of the target clusters over 75 trials at each stage of the intervention programme. Generalization was operationally defined as 70% correct production of initial /s/-clusters during conversational speech. James produced the individual
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treatment words without instructional feedback by session 6. In the context of sentences, however, errors were observed for both words with clusters, and the sentences themselves, as shown below.

1) We start on that [wi sat on sðæt] – an /s/-cluster, but on that, not start.
3) Make Spot [mæt sopot] + gesture indicating action for Spot, and Make, I know what, make S(pot) paint [mæt æ1 noʊ wɒt mɛt sə ʃeɪnt] – word retrieval difficulties, shown by use of partial word formation, fillers, and gestures.

By session 10, James did reach the performance criterion for sentences without instructional feedback, but showed minimal use of /s/-clusters in conversation even by session 16. This progress was notably slower than that of other children in the intervention project, and therefore several intervention variables were altered in accordance with evidence from the literature (see Baker and McLeod, 2004, for details): treatment targets (or goals), training exemplar number, treatment techniques, and parent involvement. The programme was broadened by the addition of more /s/-clusters (/sw, sl/) and velars. Velars /k,ɡ,ŋ/ were the only segments James could not produce spontaneously or in immediate imitation; thus, like the /s/-clusters, they were selected for treatment in accordance with evidence showing greater gains for segments with ‘least phonological knowledge’ (Gierut, 1998a; Powell, 2003). The number of training exemplars was increased from 10 to 15 minimal pair words and more drill was used, in order to increase practice opportunities. For the drill sequences, James was asked to produce five to 10 correct repetitions of the requested object or action during the computer activity, and then to use the mouse himself to satisfy his request. In order to expand the context of treatment, James’ parents were asked to provide conceptually based feedback at home on his /s/-cluster production in conversational speech. They were asked to make requests for clarification (for example, ‘Do you mean nail or snail? Tell me again’) when he failed to use initial /s/-clusters, and acknowledge that they understood him when he did use them (for example, ‘Oh, the snail, I know what you’re talking about now’). This feedback was similar to the feedback given in the treatment sessions. Following another 16 sessions, James produced /s/-clusters in conversation, but still not velars.

Midstream programme adjustments appeared to help accelerate James’ phonological development, although only for the /s/-clusters, which had been targeted longer than velars. The question for this paper was whether there was information in the assessment data that would have led to a different programme from the outset. The rest of the current paper focuses on variables
that affect the intervention process, and how they might have been considered from the outset in programme planning for James, and by extension, for other children, both at the beginning of intervention and when slow progress is evident. This discussion has an everyday clinical focus rather than a research focus. In controlled intervention research studies, some variables are held constant, and others are manipulated, in order to determine the relative contribution of the many variables to outcomes. Research has not yet provided an answer as to the most critical variables for maximizing progress during phonological intervention for groups or individuals (Kwiatkowski and Shriberg, 1998). For the current paper, it is assumed that ‘real-life’ intervention has the greatest chance for success when as many variables as possible are taken into account for a given child, both at the beginning of intervention and as intervention progresses. Thus, a range of client- and treatment-related variables are considered in this paper.

Factors affecting success in phonological intervention

A number of diverse interactive variables affect the rate of progress in phonological intervention. Table 2 outlines major intervention variables in terms of the client, the treatment, and the therapist (based on Kwiatkowski and Shriberg, 1993; 1998; Powell, 2002). How client–treatment–therapist variables interact with one another, and which are most important for which children is not known. However, when therapy fails to result in sufficient change, all the variables can be revisited, to determine the potential for programme alteration.

James’ case study revisited

In the following discussion, James’ assessment profile is examined more closely to determine whether client- and treatment-related variables may have suggested an alternative intervention plan from the outset. It is of course impossible to test this alternative plan after the fact, except as they appear to be supported by the midstream programme adjustments. Given the space limitations, not all variables in Table 2 can be addressed. The therapist was a constant factor, and thus that variable was not manipulable. Client-related variables discussed in this paper include linguistic, oral-motor, personal–social, family, and phonological form variables. Treatment-related variables include treatment approaches, treatment targets, stimuli, and plans for addressing the goals. Because client
Table 2 Variables that impact on success in phonological intervention

<table>
<thead>
<tr>
<th>Locus</th>
<th>General area</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>Cognitive/linguistic</td>
<td>Problem-solving, knowledge, memory, attention, processing, language production, language comprehension</td>
</tr>
<tr>
<td></td>
<td>Physical</td>
<td>Oral mechanism structure and function, general motor abilities, stimulability, perceptual acuity</td>
</tr>
<tr>
<td></td>
<td>Personal-social</td>
<td>Motivation, social–emotional status, learning style, communicative awareness and style</td>
</tr>
<tr>
<td></td>
<td>Family</td>
<td>History of speech and/or language impairment, education, belief in treatment, therapy involvement</td>
</tr>
<tr>
<td></td>
<td>Phonological form</td>
<td>Phonetic and word structure inventories, patterns relative to adult system, severity in delay, variability</td>
</tr>
<tr>
<td></td>
<td>Phonological processing</td>
<td>Ability to repeat nonsense words, interaction of phonology and other language domains, phonological awareness</td>
</tr>
<tr>
<td>Treatment</td>
<td>Approaches</td>
<td>Relative amount of cognitive training (awareness, self-monitoring), perceptual training, oral-motor facilitation; latency and schedule of feedback and prompts or cues</td>
</tr>
<tr>
<td></td>
<td>Goals (targets)</td>
<td>Theoretical perspectives underlying goal selection, for example, targets reflecting most or least phonological ‘knowledge’</td>
</tr>
<tr>
<td></td>
<td>Plan for addressing</td>
<td>Sequential (one target at a time); horizontal (more than one target at a time); cyclical (targeting one or more goals for a set period of time, then introducing a new goal regardless of progress with the previous goal; recycling through goals in time blocks as needed)</td>
</tr>
<tr>
<td></td>
<td>treatment targets</td>
<td>Level of production from isolation to syllable to word to phrase; number of exemplars</td>
</tr>
<tr>
<td></td>
<td>Stimuli</td>
<td>Number, type, quality</td>
</tr>
<tr>
<td></td>
<td>Responses expected</td>
<td>Types, frequency, reinforcement schedules</td>
</tr>
<tr>
<td></td>
<td>Session activities</td>
<td>Types, frequency, reinforcement schedules</td>
</tr>
<tr>
<td></td>
<td>Service delivery</td>
<td>Direct/indirect; individual/group; location; participants; frequency and duration of sessions</td>
</tr>
</tbody>
</table>

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variables influence treatment targets, approaches and plans, the discussion of the
two sets of variables is interleaved, using the client-related variables as the
framework. By definition, a client-centred approach begins with the client.
Treatment variables are altered to match the client variables. The major part of
the discussion concerns goal selection and sequence, outlining how a nonlinear
phonological framework would have led to a different set and sequence of goals
from the outset. This is in accordance with the perspective of other researchers
such as Gierut (2001) and Williams (2003), who note that a critical variable in
phonological intervention outcomes is initial goal selection.

James’ general language abilities and implications for treatment
If a child has impairments in several language domains, breakdowns can occur
in one domain as complexity increases within another. When both sentence
formulation and phonology are deficit areas, the two can have a mutually
negative influence on one another during complex tasks (as shown in Panagos
et al., 1979; Prelock and Panagos, 1989). Crystal (1987) describes this as a
‘bucket’ theory of language disability. The interaction of the two or more
impairments can have implications for treatment (see below).

Did James have linguistic impairments above and beyond his phonological
impairment? During intervention, James had difficulty at the sentence level of
the programme, showing breakdowns in both sentence formulation and cluster
production. Was there evidence of language impairment at assessment that
may have altered the treatment approach? In spite of performance within
normal limits on the CELF-P (Wiig et al., 1992), his MLUm was below
average (Miller, 1981). A re-evaluation of the speech samples indicated that he
could not name some colours and shapes at age four, a possible indication of
delayed concept development. The relatively low MLUm and vocabulary
deficits in the language sample were not strong indicators of language
impairment (because sampling context or personality can result in low
output in initial sampling situations) but perhaps suggested the need for a
more in-depth evaluation, and treatment approaches that took complexity of
sentence stimuli into account. Supplementing standardized testing with
language sample analyses provides a way to evaluate language use in more
ecologically sensitive contexts.

The literature is not in agreement about best practices for intervention when
there are multiple linguistic impairments. Some research indicates that
language intervention can indirectly result in gains for phonology (Hoffman
et al., 1990; Tyler, 2002; Tyler et al., 2002). Tyler (2002: 71) states that
language intervention ‘may increase automaticity and indirectly provide
increased processing capacity for focusing on phonological forms, as predicted by interactive models of language processing.' Other research indicates that phonology does not improve when indirectly targeted with language intervention (Fey et al., 1994; Tyler and Sandoval, 1994). The differences in the literature make it difficult for therapists to make evidence-based decisions confidently. Until the debate in the literature is resolved, therapists need to be judicious in their approach to treatment. When targeting one domain, it may be advisable to reduce complexity in other domains (Reed, 1992), in accordance with the ‘bucket’ theory of language disability (Crystal, 1987). James may have benefited from a more gradual introduction to sentence production with the new phonological targets, beginning with simple repetitive two-word phrases, and then gradually increasing the length, rate, and complexity of stimuli sentences.

**James’ oral-motor functioning and implications for treatment**

The literature is equivocal on the relative effectiveness of awareness (conceptual) versus imitative approaches involving phonetic cues for articulation and phonological intervention. Powell et al. (1998) report that the conceptual approach was not as effective as intervention involving production practice for the children in their study. On the other hand, researchers such as Hoffman et al. (1990) and Howell and Dean (1994) emphasize the effectiveness of more naturalistic conceptual approaches. If the evidence is equivocal in this regard, are there any indicators within individual children (such as James) that suggest the need for one approach versus the other, or one approach more than the other?

James scored within normal limits on tests of oral-motor structure and function, as detailed in Table 1. The tests used (Ozanne, 1992; Robbins and Klee, 1987) rely on clinical judgement. A hindsight review of the video of James during Ozanne’s Oromotor Test (1992) did indicate some slowness in initiation of selected movements, although not so much as to affect his score on the test. James was unable to imitate velars, but had a wide variety of other segments and word structures in his inventory, including later-developing affricates, /r/ and /l/. Thus, the inability to produce velars was not a strong indicator of oral-motor impairment. In hindsight, a more accurate and unambiguous procedure for determining whether some oral-motor difficulties underlay James’ phonological impairment may have been helpful (such as the procedure documented by Thoonen et al., 1999).

Whether or not James had any oral-motor impairment, hindsight revealed that he produced /s/-clusters in the first session only when phonetic (motoric) cues were used in conjunction with conceptually based feedback (similar to
the children in the Powell et al. 1998 study). This may have suggested a need for a greater focus on phonetic cues and drill in his treatment programme, in order to promote automaticity of target production. Drill was included after the first 16 sessions, and results were successful for /s/-clusters. Whether the drill was instrumental in facilitating his progress for /s/-clusters is unknown, but it may have helped (although the velars did not change in that period). Through hindsight, two observations can be made: 1) passing an oral mechanism examination may not obviate the need for phonetic cues in phonological intervention for some children; and 2) in early phases of intervention, it may be advisable to include both conceptual and motoric approaches, focusing on the method that promotes the greatest gain for that child.

One final issue to consider when addressing the variable of ‘oral motor’ ability, is whether oral-motor (nonspeech) exercises would have been of any benefit to James. According to Pannbacker and Lass (2002) the use of oral motor exercises is widespread in clinical practice. However, according to Lof (2003: 9) ‘there is little, if any, theoretical, philosophical or clinical justification for using oral-motor exercises to improve speech sound production skills’. Forrest (2002: 22) supports this position in a review of research on the benefit of oral-motor exercises, by stating that ‘empirical studies on the impact of oral-motor exercises on speech remediation do not provide support for the utility of these procedures’. In light of the literature, oral-motor (nonspeech) activities would probably not have contributed to more expedient clinical outcomes for James.

**Personal–social and other child-internal variables: communicative awareness and implications for treatment**

Researchers have suggested that a child’s insight into the problem may be a key variable in terms of treatment progress (for example, Kamhi, 2000; McLeod and Bleile, 2004; McReynolds, 1987; Panagos, 1996; Ripich and Panagos, 1985; Weiss, 2004). Furthermore, Baker et al. (1999) found that children with phonological impairments who attempt to repair their messages in the face of communicative breakdown tended to progress more quickly than those who did not. James’ communicative behaviour and comments during the early treatment process appeared to show limited understanding about communication and his speech difficulties. He commented that he liked coming to the clinic to ‘play computer games’ or ‘play with playdough’. When faced with communication failure, James changed the topic, ignored requests for clarification, or simply repeated his previous utterance.

Although it is often difficult to determine what a child thinks about speech therapy and communicative effectiveness at assessment, some indication of
From hindsight to foresight

this can usually be found in early phases of intervention, as James’ comments above show. The child’s approach to intervention can have several implications for treatment goals, approaches, activities, and service delivery models. The treatment approach for James may have needed to include a focus on communicative effectiveness, in addition to phonology. Treatment activities that focused on communicative success may have helped him understand the importance of intelligible speech (for example, barrier games). This was found to be helpful for a participant in another phonological intervention study (Bernhardt and Stemberger, 1998; 2000: Colin), who generalized treatment targets to conversation only after barrier games were used. Alternative service delivery models involving groups of children (preschool programmes, speech therapy groups, sibling involvement) may also have given him an opportunity to gain insights into communicative effectiveness through peer interactions.

James received conceptually based feedback during treatment, which in retrospect appears to have been fully warranted. During the study, minimal opposition contrast therapy was used. One of the aims of that approach is to raise children’s awareness of their need to use adultlike phonemic contrasts in their phonology. Conceptual approaches that emphasized self-monitoring and metaphonological awareness may have further helped accelerate his progress; for example, Metaphon (Howell and Dean, 1994), Imagery (Klein, 1996), Parents and Child Together (PACT) therapy (Bowen and Cupples, 1999), or metaphonological intervention (Hesketh et al., 2000). Focusing on communicative and phonological awareness may not only have accelerated change in phonology, but also have had a more general impact on his phonological awareness and preliteracy skills (Harbers, 2003; Major and Bernhardt, 1998).

Speech perception is another aspect of phonological knowledge. James’ hearing was found to be within normal limits, but no other auditory perceptual tasks were included in his assessment. According to Rvachew (2003), children who exhibit ‘superior’ progress during phonological intervention may do so because they have adultlike perceptually based underlying representations, which may allow them to self-monitor and self-correct independently. The converse of this suggestion is that children like James, who exhibit slow progress, may do so because of deficiencies in perceptually based underlying representations (but see the nonlinear discussion later in this paper). The practice of focusing exclusively on speech production during phonological intervention is not new (for example, Gierut, 1998b). However, empirical evidence (Rvachew, 1994; Rvachew et al., 1999) supports the use of speech perception training to enhance speech production for some children. In hindsight, James’ progress may have been faster if conceptual approaches had included both speech perception and production training.
Family history and caregiver support
James had two first-degree relatives (elder brothers) with a history of communication impairment. Whether his family history of communication impairment reflected biological or environmental factors, James’ language development may have been compromised because of the lack of strong speech and language models from his older siblings. As noted previously, a home programme was not part of James’ treatment regimen in the first block of treatment because of study design issues. In the second half of his treatment programme, his parents were asked to provide feedback to him on his use of /s/-clusters in conversation at home. During that period, the /s/-clusters did generalize to conversation, a coincidence perhaps, but nonetheless notable.

Both authors promote and support parental involvement in treatment programmes outside of rigorously controlled treatment studies such as Baker (2000). It may have been valuable to have James’ parents and the preschool teacher conduct specific follow-up activities from the outset. His parents believed that speech therapy could be effective, and thus may have been willing and able to help him practise more often, enhancing communication overall in the home environment with him and his siblings.

James’ phonology: revisiting the analyses, goals, and plan for addressing goals
At assessment, both a phonological process analysis and a phonetic inventory analysis were used to describe James’ phonological system and to set goals. He had a large phonetic inventory across word positions, which included some later-developing phonemes (affricates and liquids). Many patterns were developmentally common: velar fronting, liquid gliding, cluster simplification and cluster reduction, occasional stopping of fricatives or dentalization of /s/. Given a phonological process analysis, /s/-clusters (/st/, /sp/ and /sn/) and velars were reasonable intervention targets. A ‘least phonological knowledge’ approach to goal selection was utilized (Gierut, 1998a). The /s/-clusters and velars were targets of choice according to that framework, because they were completely absent from his system.

The goal attack strategy (that is, the plan for working on identified treatment targets) was sequential (one goal at a time), starting with /s/-clusters. The assumption was that systemwide change would occur as a result of treating these often later-developing targets. However, this did not happen, and in the second phase of the programme, a horizontal goal attack strategy (more than one goal at a time) was introduced, with velars as the other targets. After 32 sessions, /s/-clusters, but not velars, were present in conversational speech.
Would a different analysis at assessment have suggested different goals, and a different goal attack strategy from the outset? As an alternative, the implications for goal-setting from the nonlinear phonological framework of Bernhardt and Stemberger (2000) are explored. This framework builds on developments in phonological theory over the past 20 years. Phonological theories develop to account better for patterns in phonological data. Current nonlinear constraint-based theories in phonology provide much more in-depth evaluation of phonological data than has ever been previously possible. This has opened up new possibilities for accelerating development in children with phonological disorders. Details on intervention studies based on the current application of this framework are available elsewhere (for example, Bernhardt, 1992; 1994b; Bernhardt and Stemberger, 1998; 2000; Major and Bernhardt, 1998). The major tenets of the framework and approach are described in the next section, but for detailed tutorials on nonlinear applications, refer to any of the previous publications.

**Nonlinear phonology and goal-setting (following Bernhardt and Stemberger, 2000)**

Nonlinear phonological theory emphasizes the hierarchical (nonlinear) nature of phonological form and the effects of that hierarchy on phonological patterns. The major division in the hierarchy is between higher-level *phrase and word structures*, and lower-level *segments* (speech sounds) and *features*. In nonlinear intervention studies by Bernhardt and colleagues, equal attention has been paid to both aspects of phonological form (for example, Bernhardt, 1990; 1992; Edwards, 1995; Major and Bernhardt, 1998; Von Bremen, 1990). Treatment programmes include systematic alternations of structural and segmental (feature) targets. Children typically progress in at least one of the targeted hierarchical levels within the first block of treatment, most often at the word structure level (Bernhardt, 1990; 1992; 1994b; Bernhardt et al., 2003; Edwards, 1995; Von Bremen, 1990).

Within the phrase and word structure level, potential new targets include: 1) new phrasal stress and intonation; 2) new word lengths; 3) new word stress patterns; and 4) new word shapes in terms of consonant and vowel sequences, for example, CVC (as in *cat*) or CCVV (as in *play*). Depending on the child's developmental level and the needs identified for each of the above, some areas may take precedence in goal-setting. For example, if a three-year old child has neither three-syllable words nor CVC words, the CVC takes precedence in goal-setting because three-syllable words are made up of various smaller syllables.
such as CVC, a highly frequent syllable and word shape in English. However, if a five-year old has no use of three-syllable words, and already has basic word shapes such as CVC and CVCV, three-syllable words may be targeted.

Within the segmental and feature levels, manner of articulation, place of articulation, and laryngeal features (voicing, glottal features) are examined, both as individual features and in combinations with each other. The assumption of nonlinear phonological theory is that features show hierarchical organization, with manner features being higher (more dominant) than place and laryngeal features in the hierarchy. Within each grouping of features (place, manner, laryngeal) some features are also considered dominant or general, for example, labial place is more dominant than details of labial articulation (the labiality of /f/ is more general than its labiodental articulation). There are other dominance relationships between features and feature values (+, −). Some are predictable (or defaults) because of high frequency in the child’s system, the particular language or across languages (for example, alveolars are most common across languages), while others are more specific to a given language and need to be learned (nondefaults, for example, the feature [+lateral] for /l/). In setting goals, features from different areas of the feature system are considered potential targets, with the more marked, nondefault features of adult phonology considered higher phonological priority. (This is similar to the notion of Gierut, 1998a, regarding selection of complex targets.) For example, if a child produces neither alveolars nor velars, the velars would be the phonological targets of choice because they are nondefaults (more marked). If there is a choice between /v/ and /z/ in English, the /v/ would take precedence because it contains three nondefault features ([Labial], [+continuant], [+voiced]) whereas /z/ only has two nondefault features ([+continuant], [+voiced]). However, individual children may have their own set of defaults (velar instead of alveolar). In that case, the goal becomes re-assignment of default values in accordance with the adult system; for a child with a velar default, alveolars would then be treatment targets. Furthermore, no matter what the phonological analysis suggests for goals, if other variables (linguistic, personal-social, hearing, motor) need to be considered in the goal selection process, defaults may be the targets of choice, particularly for children who need a slower, developmental approach to intervention (see McLeod and Bleile, 2004; Weiss, 2004).

The third area of analysis and subsequent goal identification concerns interactions between segments (features) and word structure. Features and segments are examined across word positions and in sequences within syllables, words and phrases. Some word positions may show limitations in feature and segment production, and thus positional or sequence goals for features and
Table 3  Framework for analysis and goal-setting in phonological intervention based on nonlinear phonological theory

<table>
<thead>
<tr>
<th>General goal</th>
<th>New form</th>
<th>New combinations or sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Introduce a form that is missing or marginal.</td>
<td>Put an existing form in new positions, sequences, or combinations.</td>
</tr>
<tr>
<td>Structural unit (word, phrase)</td>
<td>Phrasal stress, intonation Word length Word stress Word shape (CV sequences) e.g., No CVC? Goal: CVC.</td>
<td>Word position or sequences: Strengthen existing word positions or sequences by adding features from other word positions. e.g., Fricatives only word finally? Goal: word-initial fricatives.</td>
</tr>
<tr>
<td>Segments (phonemes) and features</td>
<td>Individual features e.g., No /l/? Goal: ([+ \text{ lateral}] /l/)</td>
<td>Make new segments by combining available features:*: e.g., fricative /s/ and labials /p/ and /b/ present, but /f/ and /v/ not: Goal: combine fricative and labial for /f/ and /v/.</td>
</tr>
</tbody>
</table>

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*Based on Bernhardt and Stemberger (2000).

*Whenever possible, nondefault (marked) features and feature values (+, −) are chosen as targets rather than default (frequent, unmarked) features. The feature or word structure is targeted using more than one segment whenever possible.

segments may need to be included in an intervention programme. Table 3 summarizes the various analyses and potential areas for treatment targets. In terms of goal-setting, there may be greater or equal focus on word structure or features in an intervention programme, depending on the child’s relative strengths or needs in the two major areas. In the nonlinear phonological intervention studies, it was found effective to use strengths at one level of the hierarchy as scaffolds for new targets at other levels of the hierarchy (Bernhardt, 1990; 1992; Bernhardt and Gilbert, 1992; Major and Bernhardt, 1998; Von Bremen, 1990). For example, if a child uses singleton /l/, but does not use clusters, /l/-clusters are potential targets. If a child uses neither /l/ nor clusters, the child may benefit first from targeting clusters with glides such as [w] (/kw/ or /tw/), with /l/ being targeted first as a singleton (as in Bernhardt, 1990; 1992). This seems to be particularly important if a child shows multiple language impairments, as in the case of James. Breakdowns can occur in one language domain when complexity increases in another (the ‘bucket’ theory of Crystal, 1987, mentioned earlier).
James: a nonlinear analysis in brief

James' speech assessment data were re-analysed using procedures from Bernhardt and Stemberger (2000) and the connected speech (open entry) module of the Computerized Articulation and Phonology Evaluation System (Masterson and Bernhardt, 2001). Nonlinear analyses can be time-consuming, but the computerized programme significantly reduced the time required and allowed for consideration of the child's dialect of English. Strengths and needs at the various levels of the phonological hierarchy were identified and are described below. [Note: The assessment data used for the re-analysis consisted of the speech samples used to complete the original analysis (see Table 5, Baker and McLeod, 2004, for a summary of the results), plus pretreatment single-word and conversational speech samples used to establish baseline performance. These additional samples were used to gain further insight into the variable cluster realizations used by James. The increase in the sample accounts for the slight discrepancies in the percent calculations between the lead paper (Baker and McLeod, 2004) and the present paper.]

Word structure strengths (structures useful for targeting new segments and features)

1) Word length: Words of up to two syllables.
2) Word stress: Words with stressed–unstressed (trochaic) patterns (as in teddy).
3) Word shape: Basic word shapes such as CV, (C)VC, CVCV, and CVCVC.

Word structure needs and potential goals

1) Word and phrase length: Words of three syllables and sentences of more than three morphemes. James' production of three-syllable words was inconsistent (8/14 matched the target in terms of syllable number); they were frequently produced with only two syllables, with unstressed syllables missing. Unstressed grammatical morphemes were often missing in James’ sentences (restricted MLUm). These two types of utterance restrictions may have been related because both involved deletion of weak syllables in multisyllabic sequences.
2) Word stress: Words starting with unstressed syllables, and three-syllable words with the following stress patterns: stressed–unstressed–secondary stress (for example, caravan) and stressed–unstressed–unstressed (for
example, *elephant*). (Because word length was restricted, stress patterns for four-syllable words are not considered here.)

3) Word shape: Word shapes including clusters. No word-initial /s/-cluster target words were produced with two consonants (100% cluster reduction); 31/81 (38.3%) approximant clusters were produced with two consonants, the rest showing reduction (61.7%). Thus, he had not yet mastered word shapes starting with two consonants (CCV, and so on), even for approximant cluster targets. Word finally, twice as many cluster targets had two consonants (21/33 or 63.7%), 12/33 showing reduction (36.3%).

**Feature and segmental strengths (features and segments for targeting new structures)**

1) All segmental categories except velars.

**Feature and segmental needs and potential goals**

1) Individual feature: [Velar] (or, in nonlinear terminology, [Dorsal]) for velar consonants (a nondefault place feature for English).

2) Feature combination: [+voiced] and [−grooved] (interdental) for /ð/ (a nondefault feature combination for English).

**Strengths in interaction between structure and features**

1) Most segments in his inventory were produced across word positions.

2) Most consonant sequences were produced accurately across vowels, that is, there were no ‘distant’ assimilations (such as [bIp] for *dip*).

**Needs in interaction between structure and features**

1) Word position constraint: /r/ was not produced word initially, although appeared word medially. (Word-final /r/ is not used in his Australian dialect.)

2) Clusters: There was a high degree of cluster reduction, especially word initially. There were variable patterns of deletion across and within cluster types, and deletion in clusters was not predictable based on sonority. There was also a wide variety of other cluster realization patterns (see Table 4).

When such variety is evident, it may be assumed at first that there is minimal systematicity to a child’s phonological system. Phonological processes describe the various patterns in his cluster realization, but miss certain key facts. A deeper (nonlinear) analysis, however, can reveal a more coherent system than the surface realizations and process descriptions suggest. A
Table 4. James' variability in cluster realization across targets

<table>
<thead>
<tr>
<th>James' cluster patterns</th>
<th>Adult cluster targets</th>
<th>No.</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC &gt; target stop or fricative + [w]</td>
<td>bl, pl, br, pr, fl, fr, dr, tr</td>
<td>18/87</td>
<td>fly [fwai]</td>
</tr>
<tr>
<td>CC &gt; assimilated stop or fric. + [w]</td>
<td>kr, gr, kw, sw, th</td>
<td>7/78</td>
<td>Christmas [pwismos]</td>
</tr>
<tr>
<td>Stop/fric. + approx. &gt; stop/fric. only</td>
<td>bl, pl, fl, gl, br, fr, tr</td>
<td>13/87</td>
<td>frog [fat]</td>
</tr>
<tr>
<td>Stop/fric.+approx. &gt; [w] only</td>
<td>dr, gr, tw</td>
<td>8/87</td>
<td>drink [wint]</td>
</tr>
<tr>
<td>/s/-stop clusters &gt; stop</td>
<td>sp</td>
<td>6/39 (6/7)</td>
<td>spin [pin]</td>
</tr>
<tr>
<td>/s/-stop clusters &gt; [s] (sometimes [θ])</td>
<td>st, sk</td>
<td>18/39</td>
<td>school [su]</td>
</tr>
<tr>
<td>/s/-nasal clusters &gt; nasal nasal</td>
<td>sm, sn</td>
<td>6/14</td>
<td>smile [maiu]</td>
</tr>
<tr>
<td>Stop/fric. + approx. coalesce to [f]</td>
<td>kw, kr, tr, θr, sw, tw</td>
<td>13/116</td>
<td>crown [faun]</td>
</tr>
<tr>
<td>Stop/fric. + approx. coalesce to [ʃ], [θ]</td>
<td>kl, kr, gl, dr, tr, sl</td>
<td>15/116</td>
<td>sleeping [tfipi]</td>
</tr>
<tr>
<td>/sp/coalesce to [φ]</td>
<td>sp</td>
<td>1/116</td>
<td>spoon [φun]</td>
</tr>
<tr>
<td>/s/ + nasal coalesce to voiceless nasal</td>
<td>sm, sn</td>
<td>8/14</td>
<td>snap [ŋæp]</td>
</tr>
</tbody>
</table>

*Approx. = approximant. Coalescence involves the merging of features from each of the consonants in the cluster into one unique consonant.

detailed discussion of James' clusters follows, in order to reveal some of the underlying motivations for his cluster productions.

Only three clusters showed a single production pattern: /sl/ (3/3) and /kl/ (5/5) were produced as [tʃ], and /pr/ was produced as [pw] (4/4). Other clusters had up to six types of productions, for example, /tr/ was produced as [t] (2/9), [tʃ] (1/9), [f] (2/9), [fʷ] (2/9) [fw] (1/9), and [fʷ] (1/9). There were a variety of patterns within the /s/-cluster category (which had been treated as a uniform category for the intervention study). In terms of reduction patterns, the /sp/ showed retention of the stop (6/7), but the /st/ and /sk/ showed retention of /s/ (18/18). The /sp/ also showed coalescence to [f] (sharing of nondefault features [-continuant] of /s/ and [Labial] of /p/ within one segment, [f]). The /s/-nasal clusters showed either coalescence (to a voiceless nasal), or retention of the nasal. The /sl/ showed coalescence (to [ʃ]), and the /sw/ showed coalescence to [f], or assimilation ([fw]). (Note: Phonological process terminology is used in this section in order to facilitate readability for persons with minimal background in constraint-based nonlinear phonology.)

Overall, labial assimilation was infrequent but did occur (10 tokens, occurring when [w] was the second element of the cluster), whereas coalescence (merging
of features from the two consonants into one) was more common (37/116, 31.9%). Coalescence for adult cluster targets with coronal (alveolar or palato-alveolar) features (/kl/, /kr/, /dr/, /tr/, /sl/) resulted in an affricate or fricative substitution ([tf]/[d3]/[ts]/[s]); these substitutions maintained the coronal place of articulation and often the [continuant] features ([−continuant] for the stops, and [+continuant] for the fricatives or approximants). Coalescence for adult targets containing labial features in second position (/p/, /w/, /r/) resulted in [f], maintaining both labial place of articulation, and the [+continuant] feature of one or more of the cluster elements.

Learning clusters means not just learning to produce two (pronounceable) consonants in a row, but to produce many different sequences of place, manner and voicing. Two salient aspects of his cluster production that can be demonstrated through a nonlinear and constraint-based analysis are as follows:

1) Place sharing for consonant cluster production. Consonant sequences that James produced all shared labial place of articulation: because of labial assimilation ([fw]), as a result of liquid simplification (/pl/ > [pw]) or labialization of /θ/ (as in /θr/ > [fr]). Place sharing is a common phenomenon in early cluster production (Bernhardt and Stemberger, 1998). Nonlinear phonology describes this as the sharing of a link between the two neighbouring identical features. If two segments are linked to the same feature, there is low complexity at the level of the feature in the phonological hierarchy; given that a child (in this case, James) has overall constraints on complexity, low complexity at the feature level of the phonological hierarchy may allow for greater complexity at the structural level, in this case, CC. Expectations for treatment would be that exploitation of feature sharing might facilitate production of more clusters. In terms of shared place of articulation, the /st/ and /sn/ targets of the ‘real-life’ intervention programme were thus fortuitous choices (all being alveolars), although the /sp/ was not (alveolar-labial). (Place sharing could have resulted in [fp], a highly marked, or unusual cluster, or [st], unlikely because of the tendency to produce labials). However, none of these targets was easily acquired by James. What else may have been involved?

2) Retention of nondefault features in deletion and coalescence. First, the /s/-stop clusters (/sp/, /st/, /sk/) had different patterns of realization. For /sp/, the labial stop was produced in James’ speech, whereas for /st/ and /sk/, the alveolar fricative /s/ was produced ([Coronal, +anterior]). The difference between the two types of /s/-stop clusters suggests that feature sequences, not sonority, were the motivating factor for cluster production. If sonority motivated the deletion pattern, all /s/-stop
processes would have been more likely to show stop retention. Given this variability in patterns, expectations for treatment would be that /sk/ and /st/ would behave similarly, and differently from /sp/.

What motivated the varied deletion patterns? It appears that feature status as default or nondefault was relevant. The [Labial] feature of /p/ is a nondefault feature, as is the [+continuant] feature of /s/. Given the two nondefaults, the place feature [Labial] dominated the manner feature [+continuant] in realization of /sp/. This is congruent with the predominance of [Labial] noted in 1) above. However, for /st/ and /sk/ (/k/ was always [t]), the fricative [s] was produced. The /s/ has default coronal ( [+anterior], or alveolar) place; production of [s] allowed feature realization of both the nondefault [+continuant] and the default coronal place feature.

Another way nondefault features were produced was through coalescence. Coalescence allows production of several features from two neighbouring segments, even if the sequence of two segments is impossible. In the case of the voiceless nasal for the /sn/, two nondefault manners were maintained, [+continuant] of /s/ and [+nasal] of /n/. In addition, /sp/ was once realized as [ṕ], showing production of both nondefault [Labial] and nondefault [+continuant]. The frequent coalescence and the production of nondefault features in deletion patterns, possibly indicated that James had underlying knowledge (representation) of the consonant features in most clusters, but constraints on production of those features in sequence. By merging the features of the two segments into a single consonant, or producing the nondefault feature in a sequence (by deleting the segment with more default features), he could be 'faithful' to the underlying segmental representation, if not to the structure of the target word. (Underlying representations in some versions of nonlinear phonological theory, for example, Bernhardt and Stemberger, 1998, contain nondefault (learned) features, whereas default features are provided automatically by the phonological processing system.) He did produce a consonant-glide sequence some of the time (with a [w] substituting for /l/ or /r/); thus, he also appeared to have underlying knowledge of the structure of two-element clusters, and some ability to produce them.

That nondefault features often survived in production, was a positive aspect of James's phonology. This could be exploited in intervention as is shown below in the discussion about goals for clusters.

In summary, although James had a wide variety of individual consonants and vowels, consonant sequences were clearly challenging because of the feature sequences involved. He showed variable realizations of these clusters, producing as many nondefault features as possible within a given segment. (Note that he
passed Dodd’s (1995) variability index, yet showed a fair degree of variability within the cluster categories and between certain words in the sample.) The /s/-clusters and the approximant clusters were not two straightforward categories, but rather a compilation of a variety of individual clusters, which just happened to have approximants and /s/. Because he showed variable realizations of the same cluster, and several coalescence patterns, he may have had fairly intact phonological representations of the clusters. On any given production, different nondefault (underlying) features could potentially surface. Which features surfaced possibly reflected constraints at the moment of production, including feature default status, speed of articulation, his knowledge of the particular word, the frequency of the particular word, and surrounding vowels, consonants, and words in the particular context. These kinds of phenomena are not atypical, but also affect adult pronunciations, resulting in speech errors (Stemberger, 1989).

**James: goals suggested by a nonlinear analysis**

In the previous section, strengths and needs in James’ phonological system were identified and a detailed discussion of James’ clusters was presented. A number of actual treatment goals were possible. According to the Bernhardt and Stemberger (2000) approach to goal selection, it is important to promote change across the various levels of the phonological system (both structures and features) from the outset. Phonology is not just a set of disconnected phonemes occurring in unstructured (linear) sequences, nor is it just a set of structures without content (features and segments). Even though one particular aspect of a child’s phonology may stand out as requiring attention (in James’ case, clusters and velars), other aspects of the system may be equally important in promoting change. Generally, strengths in one aspect of the system can be used effectively as scaffolds for promotion of new targets at other levels, especially for children who show multiple impairments across language domains (such as James). This does not mean that difficult, later, or complex targets are avoided, but that the strategies for attacking that target try to engage system-inherent supports. Table 5 lists goals and sequence suggested by the analysis, which are discussed below.

**Word and phrase structure goals**

*Production of weak syllables in phrases and three-syllable words.* In terms of phrase and word structure, James’ reduced MLUm and deletions in multisyllabic words may have been part of the same problem: he had difficulty producing unstressed syllables in longer utterances. These could have been
Table 5 Revised phonological goals for James for the first treatment period, suggested by a nonlinear analysis

<table>
<thead>
<tr>
<th>Word and phrasal structure</th>
<th>New form</th>
<th>New combinations or sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Phrases and three-syllable words with retention of unstressed syllables</td>
<td>1) Word-initial /r/</td>
<td></td>
</tr>
<tr>
<td>2) CCV(CVC)</td>
<td>2) Clusters with different places, manners, and voicing: /pl/, /bl/, /sl/, /fr/ (word-final /st, sp/)</td>
<td></td>
</tr>
<tr>
<td>3) (CVCC)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Segments and features

Individual feature: [Dorsal], that is, velar (word finally with back low vowels first) (Feature combination: [+voiced]+[−grooved]+ [+continuant] − /ð/)

Note: Targets in parentheses would be considered low priority alternatives.

addressed independently, or as two instantiations of the same goal, that is, the maintenance of weak syllables in rhythmic strings (unstressed grammatical morphemes or syllables within words). Bernhardt and Stemberger (2001) reported on a successful intervention programme with a child with similar restrictions. This particular goal was not identified in James’ ‘real life’ intervention programme, which did not draw links between the reduced MLU(m and the phonology. This is fairly typical of phonological process analyses and ‘least phonological knowledge frameworks’, which focus on single word phonology, rather than phrasal phonology.

Production of clusters. There were two subgoals for James’ clusters: 1) production of a structural unit CC; and 2) production of CC with different place, manner, and voice features. The process analysis and ‘least phonological knowledge’ approach targeted /s/-clusters as a unitary category, because they showed more reduction than approximant clusters, and were developmentally later targets. The particular clusters of choice for the first phase of the intervention programme were /st/, /sp/ and /sn/. Alternatives to those specific cluster targets are outlined below, with advantages and disadvantages of the various targets suggested. Generally, more than one exemplar of a category is targeted in a nonlinear treatment programme, in accordance with the perspectives that: 1) it is impossible to predict what will be most facilitative for a given child until therapy has begun; and 2) targeting more than one exemplar of a category strengthens the possibilities for generalization. Once James could consistently produce one or two of the clusters consistently, others would have been introduced in subsequent treatment blocks. Following principles in Bernhardt and Stemberger (2000), strengths
in one area of the system would be used to support needs in other areas (as scaffolds). There were several strengths in James’ system upon which to build new sequences: a wide variety of segments, the ability to produce same-place clusters, and the production of nondefault features of cluster targets. These could be exploited in different ways, as the alternatives demonstrate.

**Alternative 1: /pl/ and /bl/ – Providing scaffolds of structural and segmental integrity.** If structural strengths were to be used as a scaffold for sequence production, the /p/- and /b/-approximant clusters would be targets of choice. These were most advanced in terms of actual CC production; they were usually produced with a [w] in second position. In terms of segmental integrity, the labial stops were well established, and the /l/ was more well established than /r/, yielding /pl/ and /bl/ as targets. A further scaffold for these sequences as targets would be that [Labial] of the stops and [+lateral] of /l/ are nondefault features, and nondefault features often survived in his productions. The [Labial]–[Coronal] sequence across vowels (as in a word like ‘bite’) often appears earlier in acquisition than [Coronal]–[Labial] (as in a word like ‘tap’; Bernhardt and Stemberger, 1998). Thus, the place feature sequence might also be a scaffold.

In spite of the various scaffolds, the sequences /pl/ and /bl/ would still be relatively challenging as sequences. They require changes in place ([Labial]–[Coronal]) and manner ([−continuant]–[+continuant], [+lateral]) and for /pl/, voicing ([−voice]–[+voice]). Targeting these particular clusters with their nondefault features might have helped overcome the cluster sequence constraints more than the intervention programme’s /st/ and /sn/ targets, which have the same default place of articulation, and the /sp/, which has a [Coronal] (alveolar)–[Labial] sequence.

If cluster reduction were the variable under consideration, /pl/ and /bl/ could be considered in direct opposition to the ‘least phonological knowledge’ approach to target selection (unlike the /s/-clusters, these clusters were infrequently subject to deletion). However, if feature sequence were the variable under consideration, /pl/ and /bl/ could still be considered challenging targets. Producing different feature sequences was one of James’ major challenges, as the nonlinear analyses show. This demonstrates the difficulty of interpreting the term ‘least knowledge’. It could have many bases, from segmental to structural to sequential.

**Alternative 2: /sl/ – Providing scaffolds of similar feature sequences and consistency.** The /sl/-cluster could have been an alternative or additional initial target to /pl/ and /bl/. Scaffolds provided by /sl/ would be similarity
in place and manner (both alveolars, and both [+continuant]), and the nondefault status of the [+continuant] of /s/ and the [+lateral] feature of /l/. Another possible scaffold may have been that James had a uniform pattern of production for /sl/ (the affricate [tʃ]). He may have found it easier to learn a new pronunciation of a target that had a consistent substitution pattern than clusters with more variable pronunciations. In ‘real life’, the /sl/ was introduced in the second half of his intervention programme, and was learned more quickly than the other /s/-cluster targets. In terms of level of phonological knowledge, the /l/ was less well established than /t/ and /n/ and so /sl/ could also have been a target in terms of the ‘least phonological knowledge’ for segments. However, in terms of phonological knowledge of sequences, /sl/ was easier than /pl/ and /bl/ because of feature sharing (again, showing the difficulty of identifying level of phonological knowledge).

*Alternative 3: Scaffolding based on cluster inventory.* Another alternative or additional target might have been /fr/, produced once as a substitution for /θr/. Targeting /fr/ may also have facilitated production of singleton word-initial /r/(another need). The /fr/ also could have been considered a target in terms of the ‘least phonological knowledge’ framework, in that the segment /r/ was only weakly established. However, again, feature similarity within the cluster (/f/ and /r/ being [Labial] and [+continuant]) meant that feature sequence knowledge for /fr/ was more advanced than for /pl/ and /bl/.

*Alternative 4: Scaffolding based on word position strengths.* Finally, taking a completely different track, word-final /s/-clusters might have been included in the first treatment block for clusters. These were more well established than word-initial clusters, but still showed a fair degree of reduction. Once he could produce /st/ or /sp/ word finally, these could have been introduced into initial position by alternations, moving the cluster from the rime of one word to the onset or beginning of another: taste > taste > tastetaste > stay. These strategies were found effective in Bernhardt (1990; 1992; 1994a).

**Segmental and feature goals**

1) Velars: The major feature goal was [Velar] (or [Dorsal], following Bernhardt and Stemberger, 2000). It may have been facilitative to target velars word finally first, after back vowels, where the dorsal part of the tongue from the preceding vowel could help with tongue placement (scaffolding based on vowel and word position context).
2) Feature combination: /ð/, [−voiced], [−grooved]: The interdental would have been a low priority. However, it might have been addressed in later treatment blocks, after he had more success maintaining weak syllables in phrases. This would have depended on his ability to handle a new segmental target in the context of a newly established phrasal target.

Order of goals and plan for addressing them
Each of the four goal types could probably have been targeted in any order, as long as they were all included in the initial treatment block. The Bernhardt and Stemberger (2000) framework (based on nonlinear intervention studies such as Bernhardt, 1990; 1992; Edwards, 1995; Von Bremen, 1990) stresses: a) the importance of addressing multiple levels of the phonological hierarchy in the initial treatment block; and b) linking word and phrasal phonology when that is especially indicated (as it was here in terms of phase and word reductions). Given James’ variability for cluster production, it may have been important to monitor consistency and variability within sessions focusing on them. Each portion of the treatment block should probably have had more than one session or week per target, in order to help him establish some success with that target before showing him something else new to learn (as in Bernhardt, 1990; 1992; 1994b).

Postscript

A year after starting intervention James was still visiting a speech and language therapist. He had also been attending school for six months. A review speech and language assessment at that time revealed progress in some areas, ongoing difficulties in others, and new problems. James’ consonant clusters were mostly adultlike. Only occasional gliding of /r/ clusters (for example, /fr/ > [fw] as in [fwut]) and singleton consonants was evident during conversational speech. Velars continued to be problematic. Although James could produce velars in isolation and could correct his production of /k/, /g/, /ŋ/, /kl/ and /gl/ in words following a request for clarification and model, he did not use velars in conversation. His language impairment was more apparent at the review point. He continued to have difficulty naming colours and shapes, despite intervention directly targeting these terms. Testing using the Bracken Basic Concept Scale, (Bracken, 1984) confirmed below average ability. Word-finding difficulties were also apparent during conversational speech. Phonological awareness testing, using the Sutherland Phonological Awareness Test (Neilson, 1995) identified below average perfor-
mance, despite six months of exposure to phonological awareness tasks in the classroom and in the clinic with the speech and language therapist.

**Summary and conclusions**

With the view of hindsight, a number of factors emerged that were relevant for James' intervention, above and beyond what was done in the first 16 sessions. Some of these factors were in fact taken into account during the second half of his programme, and resulted in generalization of /s/-clusters after 16 more sessions. These were:

1) Continued use of both conceptual and phonetic feedback, within the context of minimal opposition contrast therapy.
2) Increased production practice, using drill.
3) Increased number of treatment words.
4) Increased number of /s/-cluster targets, with /sl/ showing success first, and then the other /s/-clusters.
5) Inclusion of home feedback on communicative success.
6) A horizontal goal attack strategy (targeting more /s/-clusters, plus velars).

With hindsight, other possibilities for the intervention programme were identified. Suggested alternatives included:

1) Step-by-step structuring of sentence stimuli for incorporation of new phonological targets, in order to accommodate deficits in sentence formulation.
2) A focus on communicative effectiveness through use of more contexts, partners, and barrier games.
3) Goals addressing all aspects of the phonological system, with specific differences in segmental goals, cluster sequence targets (addressing the feature sequence needs), and word and phrase structure goals.
4) The use of strengths within the system to address needs (a scaffolding approach), for example, starting with clusters that were more frequently realized with two elements such as /pl/, /bl/, /fr/, or with word-final clusters, alternating them to derive word-initial clusters.
5) Alternative treatment approach incorporating metaphonological awareness and speech perception training, depending on results of more extensive assessment of his speech perception and processing abilities.

Hindsight is always easier than foresight, and in this case, has the additional advantage of being untestable. It is impossible to know whether the
recommended alternatives would have helped James, although the successful midstream programme adjustments suggest that they may have done so. Evidence from other nonlinear phonological intervention studies (where most of these factors were included) suggests that change might have been faster, if the programme had been different from the outset (for example, Bernhardt, 1990; 1992; Bernhardt et al., 2003; Bernhardt and Major, in press).

When searching for ways to maximize treatment effectiveness and efficiency, there are many client-, treatment- and therapist-related variables to take into consideration. Ideally, all relevant variables would be taken into account from the outset of intervention to circumvent potential barriers to success. However, some barriers may only appear during the course of intervention. Systematic consideration of client, treatment and therapist variables (as is done with hindsight in the current paper), both before and during intervention, may help the therapist, family, and teacher plan and modify intervention programmes, so that the child’s speech development accelerates, and the risk of longer-term difficulties (social, academic) is minimized.

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