Investigating Intervention: Phonological therapy in a psycholinguistic framework

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CHAPTER 7: RACHEL

Chapter outline Page

There are relatively few studies that have investigated children's development of consonant clusters. Those that have (e.g. Allerton, 1976; Powell and Elbert, 1984; Smit, 1993; Gierut, 1999; Gierut and O'Connor, 2002) have focussed largely on word-initial clusters. Indeed, Chapter 6 was concerned with the development of word-initial consonant clusters and investigated a child's cluster development by manipulating clusters in intervention. However, in English, consonant clusters also occur in word-final positions and there remains a great deal of uncertainty regarding the development of these clusters both by children with normal phonological development and those with difficulties. Most research that has focussed on final consonant clusters has done so by looking at children's spelling rather than focussing on speech production. Treiman, Zukowski and Richmond-Welty (1995) investigated children's spelling of words with word-final consonant clusters in order to access their representations of these sounds. They found that first grade children frequently had no representations of the first element in word-final clusters, i.e. post-vocalic nasals or liquids in non-words such as 'pilt' or 'sanch' were not represented in spelling as separate phonemes, but rather considered to be attributes of the vowel.

Bridgeman and Snowling (1988) compared the perception of phoneme sequences by children with dyspraxia with those with normally-developing speech. The research focused on children's auditory discrimination of word final clusters [st] and [ts] using a same / different paradigm with word pairs such as [fɪts] and [fɪst]. They found that both groups of children could discriminate real words equally well, but that the dyspraxic children had problems in non-word discrimination. Using these word final clusters seemed to pose particular challenges for the children with speech difficulties. The authors suggested that this difficulty is due to children having difficulties with sequential aspects of phonological processing.

In terms of a developmental sequence, word-initial consonant clusters are sometimes acquired before and sometimes after word final consonant clusters (McLeod, van Doorn and Reed, 2001). Nevertheless, most normally-developing children have no difficulty in the perception or production of word-final consonant clusters. Rachel, the child who forms the focus of this chapter, presented with age-appropriate language and literacy skills, and speech that was moderately intelligible to unfamiliar listeners. Closer examination of her speech revealed that subtle difficulties persisted: she frequently stopped [s] to [t], and also experienced difficulties in the sequencing of [s]+stop clusters in word-final position. This chapter attempts to understand the underlying cause of such difficulties, and to describe the way in which such subtle, yet longstanding difficulties responded to intervention.

A secondary theme of the chapter is that of resilience. Whilst it is known that many children with persisting speech problems will go on to experience literacy (Bishop and Adams, 1990) and language difficulties (Bishop and Clarkson, 2003), Rachel was considered above average in both these areas. She appeared to be resilient in her response to her speech difficulties. This important – but under-explored concept – is investigated in the chapter. Section 1 considers Rachel's background. In Section 2, Rachel's assessment is described, and this is followed by sections on macro (section 3) and micro (section 4) intervention planning. These sections outline the rationale underpinning the intervention, both in terms of the psycholinguistic focus and the phonological analysis which led to the selection of word-final consonant clusters as targets for intervention. Section 5 describes Rachel's intervention programme. Section 6 is an evaluation of the intervention outcomes, followed by a discussion of the intervention and associated themes in section 7.

1. BACKGROUND INFORMATION

Rachel was 7;1 at the start of the study and in Year 2 in a mainstream school. Her involvement in the study continued until she was 8;10 and in Year 4.

1.1. Developmental

Rachel is a right-handed girl whose birth and early developmental history is normal in all aspects with the exception of her persisting speech difficulties. Her parents reported that she spoke her first words a little later than her older brother. No hearing difficulties or middle-ear infections have been reported at any stage. Motor milestones were achieved within normal age limits. No feeding difficulties were noted.

1.2 Educational

Rachel achieves well at school and is in the 'top group' for all her subjects. Her class teacher describes her as academically well-above average. She is conscientious and hard working. Rachel's language and literacy skills are good for her age, and she enjoys both reading and writing. She has good attention in a one-to-one situation and can generally sustain her attention in the classroom situation, although at times she needs to be re-focussed on the task at hand. IQ results (WASI, Wechsler, 1999) suggest a verbal IQ of 82, a performance IQ of 100 and a full-scale score of 89.

1.3 Medical

Rachel's medical history is uneventful with no serious episodes of illness or hospitalisation. She suffered from asthma when she was younger. She continues to suffer from eczema and seasonal allergies.

1.4 Speech and language therapy

Rachel was first referred to speech and language therapy at CA 3;9 by her nursery teacher who found her difficult to understand. Initial assessment revealed good symbolic play and sentences of three-four words. Her sound system was however, described as extremely disordered with a limited repertoire of sounds, and consistent fronting, stopping and voicing affecting her intelligibility. A series of speech therapy sessions was offered with Rachel attending approximately 7 of these. Rachel was discharged after this input due to non-attendance.

Rachel was referred by her school some 18 months later at CA 5;1 as her reception class teacher and the school nurse were both concerned about her unclear speech and the fact that she continued to "mispronounce words, seemingly forming her words in the front part of her mouth." Rachel's class teacher also expressed concern that Rachel's speech difficulties were impacting on her ability to read and write. Rachel was re-assessed in January 2000 at which time it was noted that her concentration was much improved; she was keen to communicate and used a range of sentence types. Again, major concerns centred on her sound system - characterised at this point by immature processes such as fronting, stopping and cluster reduction, resulting in immature-sounding speech that was unintelligible out of context. Although Rachel's family understood her, they recognised that strangers often had more difficulty. Her parents reported that they had been disappointed by the previous therapy that seemed to have little effect and focussed heavily on play. The nature of therapy was explained and it was agreed that Rachel would attend further sessions of therapy focussing on her speech production.

This 'block' of therapy was initiated some 6 months later in June 2000. Rachel (CA. 5;6) attended 5 sessions of weekly (45 minutes duration) therapy which focussed on her production of phonemes including [k], [g], [f] and [s]. Articulation therapy was carried out with Rachel being encouraged to produce the sounds in isolation in the first instance, then moving to consonant-vowel (CV) sequences and on to longer words and sentences. Progress was reported following these sessions and Rachel was placed on the review list to monitor her progress in the future. Rachel did not attend her review appointment some three months later. In November 2000, the school again expressed concern about Rachel's immature speech and difficulties in understanding her.

Rachel was then seen in school on a termly basis by a speech and language therapist, (SLT) with day-to-day work being carried out by a support teacher in the school under the guidance of the SLT. This work aimed to encourage Rachel to produce [k] and [g], as well as fricatives such as [s] and [f] which were absent from her repertoire. Rachel remained on the NHS caseload at the time of the study, and her assessment and intervention was carried out in close collaboration with her NHS therapist.

1.5 Family

Rachel lives with both parents and is a middle child with two male siblings. Rachel's mother stays at home looking after the children. Her father is a long distance truck driver who spends considerable periods away from home. Rachel's grandparents live close to the family and she has a close relationship with them, as well as with her many cousins, aunts and uncles who live in the same area.

1.6 Social and emotional

Rachel is a quiet girl who sometimes needs to be encouraged to express her opinions in the classroom situation. In the one-to-one situation with an adult, she was initially shy but once she gained confidence was talkative and friendly. Rachel has many friends, mainly girls of a similar age in her class, as well as some older girls in the class above hers. She seems to form bonds easily with children and adults, and has a kind and caring personality.

Rachel is an insightful, sensitive child who has some awareness of her speech difficulties. Both her class teacher and her father reported incidents in which she was upset by other children or adults commenting on her immature speech.

1.7 Summary of background information

Rachel has a normal developmental history with no significant medical or social factors to report. Academically she is making pleasing progress and has good potential to do well at school. Rachel has persisting difficulties with her speech production: she spoke slightly later than her older sibling, and her speech has been a cause of concern to her family, her teachers, the school nurse and now, increasingly, to herself. Her speech has been variously described as 'immature,' 'unclear' and 'unintelligible to strangers.' Rachel has received speech therapy - approximately 12 hours of direct therapist contact over the course of ~4 years. However, difficulties remain and there is concern that Rachel may be at risk for experiencing spelling and reading difficulties linked to her persistent speech problems.

2. ASSESSMENT

Assessment was carried out at the start of the study when Rachel was in Year 2 (CA 7;1 – 7;4). The entire assessment procedure was revisited on completion of the intervention, when she was in Year 3 (CA 8;2 – 8;3) and at long-term follow-up when she was in Year 4 (CA 8;9 - 8;10). Assessment was grouped into four main areas: (1) standardised language assessment, (2) speech profiling carried out within the psycholinguistic framework, (3) phonological analysis, and (4) child interview and parent / teacher report. Results of the standardised assessments are presented in section 2.1, followed by a discussion of the speech profiling (2.2), speech analysis (2.3) and child interview and parent / teacher report (2.4). The re-assessments are discussed in the evaluation sections of the chapter.

2.1 Standardised language assessment

The results of the standardised assessments are summarised in Table 7.1.

Table 7.1
Summary of Rachel's standardised speech, language and literacy assessment at CA 7;1

Assessment	Area tapped	Standard score	Centile	Age equivalent
Receptive Language				
Test of reception of grammar (TROG, Bishop, 1989)	Receptive grammar	104	62.5	9;0
British Picture Vocabulary Scale (BPVS, Dunn et al., 1997)	Receptive vocabulary	88	22.5	6;2
Clinical Evaluation of Language Fundamentals (CELF- 3), Receptive Subtests (Semel et al.,1995)	Receptive language	10	50	Age-appropriate
Expressive Language				
Renfrew Word Finding Vocabulary Test (Renfrew, 1995)	Expressive vocabulary		25	5;8
Clinical Evaluation of Language Fundamentals (CELF- 3), Expressive Subtests (Semel et al.,1995)	Expressive language	9	40	Age-appropriate
Edinburgh Articulation test* (EAT, Anthony et al., 1971)	Articulation and naming	77		5;6
Literacy Measures				
Schonell Graded Reading Test (Newton and Thompson, 1982)	Reading single words			Reading age = 7;9 years
Schonell Spelling Test (Newton and Thompson, 1982)	Writing single words from dictation			Spelling age=8;6

* EAT is designed for use with children up to the age of 6;0. Rachel's scores were calculated using this upper age limit although she was 7;1 at the time of the assessment.

The general speech, language and literacy assessment revealed that Rachel had skills in each of these areas. Rachel performed slightly below age on both the expressive and receptive vocabulary tests. Both Rachel's reading and spelling skills are beyond what one might expect for a child her age. Bishop and Adam's (1990) critical age hypothesis suggests that children whose speech difficulties persist beyond the critical age of 5;6 are at increased risk of experiencing literacy difficulties. However, Rachel does not seem to be showing any literacy difficulties despite these predictions.

2.2 Speech profiling in a psycholinguistic framework

The speech processing profile was used as a framework for this part of the assessment. At each level of the profile, excluding level C which is not routinely assessed in monolingual children (Stackhouse and Wells, 1997), at least one assessment was carried out. In some cases these were standardised measures, and in other cases consisted of unpublished and non-standardised materials (see Appendix 2). The ticks and crosses on the profile indicate Rachel's performance in relation to children of her chronological age, with one tick indicating age-appropriate skills, and further ticks or crosses showing the number of standard deviations above or below the mean. The completed profile is presented in Figure 7.1.

2.2.1 Overview of psycholinguistic speech processing profile

Rachel has strengths and weaknesses scattered throughout her speech processing profile, on both the input and output sides. There is great variability at each level of the profile: she can do tasks at most levels of the profile and her speech processing system is intact, at least for the basic requirements. If one considers levels D, I and J (in fig 7.1), Rachel can do some of the more simple, standardised tests in line with her peers. However, complex and unusual tasks (e.g. level B, Bridgeman and Snowling's (1988) non-word discrimination task, see Appendix 2a) outface her.

2.2.2 Strengths

Rachel has good phonological representations and her awareness of the internal structure of phonological representations (levels E and F, fig 7.1) is adequate. These 'top-down' strengths on the input side of the profile are mirrored in the considerable improvement in her performance on auditory discrimination between real words as opposed to the weaker skills evidenced further down with non-word auditory discrimination (level B). Rachel's strengths are variable in terms of output: She is able to manipulate phonological units (level H) with a high degree of skill and has adequate sound production skills at the lowest level of output (level K).

Figure 7.1
Rachel's speech processing profile at CA 7;1 (from Stackhouse and Wells, 1997)
√ = age appropriate performance
X = 1 s.d below the expected mean for her age
XX = 2 s.d below the expected mean for her age
XXX = 3 s.d below the expected mean for her age

INPUT

F Is the child aware of the internal structure of phonological representations?
√ - Rhyming test (Vance et al. 1994)
√- PhAB picture alliteration subtest (Frederikson et al. 1997)

E Are the child's phonological representations accurate?
√ - Auditory lexical decision task (Constable et al., 1997)
√ - Sorting tasks

D Can the child discriminate between real words?
X – Real word discrimination test (Bridgeman and Snowling 1988)
√ - Aston index discrimination subtest (Newton and Thompson 1982)
√- PhAB alliteration subtest (Frederikson et al. 1997)

C Does the child have language specific representations of word structures?

Not tested

B Can the child discriminate speech sounds without reference to lexical representations?
XXX – Non-word discrimination test (Bridgeman and Snowling 1988)

A Does the child have adequate auditory perception?
√ - audiometry

OUTPUT

G Can the child access accurate motor programmes?
X – Single word naming test (Constable et al., 1997)
√ – Word-finding vocabulary test (Renfrew 1995)
X – Edinburgh articulation test (Anthony et al. 1971)
X – The Bus Story (Renfrew 1969)

H Can the child manipulate phonological units?
√ - PhAB Spoonerism subtest subtest (Frederikson et al. 1997)
√ - PAT rhyme fluency subtest subtest (Muter et al. 1997)

I Can the child articulate real words accurately?
X – Real word repetition subtest (Constable et al., 1997)
√ - Aston index blending subtest – real Words (Newton and Thompson 1982)
√ - Real word test (Snowling)

J Can the child articulate speech without reference to lexical representations?
√ – Aston index blending subtest – nonwords (Newton and Thompson 1982)
X – Non-word repetition subtest (Constable et al., 1997)
√ - Non-words test (Snowling)

K Does the child have adequate sound production skills?
√ - Stimulable for all sounds
√ - Oro-motor assessment (Nuffield Dyspraxia Programme, Connery et al. 1994)

L Does the child reject her own erroneous forms?
No

2.2.3 Weaknesses

Most striking is Rachel's difficulty with the non-word discrimination task (level B, Bridgeman and Snowling's (1988) test, see Appendix 2a). Rachel's score is several standard deviations below that of her peers. She was able to discriminate between [s] and [t] segments (e.g. [fɒs] v. [fɒt]) but found it extremely difficult to discriminate between sequences involving these phonemes (e.g. [fɒst] v. [fɒts]. Her performance improved when faced with real words (level D, Bridgeman and Snowling, 1988), although the [st] and [ts] sequences remained problematic for her even within real words. For the input side of the profile, auditory discrimination of closely related consonant sequences, particularly in non-words, is her major weakness. This may have important implications for her new word learning, which may explain her lowered vocabulary score in Table 7.1

In terms of output she has pervasive weaknesses in her accessing of some stored motor programmes, as well as the online creation of new motor programmes (level G) in non-word repetition tasks. Rachel was able to repeat simple words accurately, but faced difficulty when words were multisyllabic and required complex consonant sequencing (level I). Transposition errors were noted on several occasions in the repetition tasks (e.g. [tætikɪlə] for CATERPILLAR), and these seem to mirror the sequencing difficulties she faced with input discrimination. Some authors have suggested that there is no evidence of a direct relationship between children's auditory discrimination and their speech output (e.g. de Montfort Supple, 1983) while others have argued for a close relationship between the two (e.g. Watson and Hewlett, 1998). In Rachel's case, there certainly did seem to be a link between her input speech discrimination errors and her speech output difficulties. Standardised tests (e.g. Aston index discrimination subtest, Newton and Thompson (1982)) did not pick up the subtle difficulties. The relationship between input and output was investigated in further detail as described below.

2.2.4 Further investigations

The speech processing profile gave a clear picture of Rachel's strengths and weaknesses but it also raised further questions. These were investigated using tasks designed specifically for the purpose and based on psycholinguistic principles (e.g. see Rees, 2001a).

(a) Is there a link between Rachel's output problems and her auditory discrimination difficulties? A test was devised which confronted Rachel with her own speech errors (e.g. are SEVEN and [dɛvɪn] the same or different? Are SPOON and [pu:n] the same or different?). Rachel found it easy to make such auditory discriminations. Locke's (1980a,b) procedure (described in Appendix 2a was carried out, which required Rachel to make judgements of her own speech errors. Rachel performed well and had a good representation of many of the words, and some awareness of her own errors. The auditory discrimination errors she made involved [s], a phoneme which she has not yet acquired fully. This may suggest a link between input and output – or alternatively it may reflect the fact that there are few reversible consonant pairs in English which involve sounds other than [s]. Rachel's auditory discrimination difficulties may be limited at this stage of her development to reversible consonant clusters - which typically contain [s].

(b) Rachel had specific difficulties in auditory discrimination of [st] and [ts] clusters, a sequencing problem (e.g. she was unable to discriminate between NEST / NETS). Was this a general sequencing problem that could be found when other phonetic combinations were tested or is it specific to [st] and [ts] pairs? In order to answer this question, a discrimination test consisting of 50 items based on Rachel's output errors was devised. Rachel had found it easy to discriminate between words which contrasted two different segments (e.g. GO v. SO) and where a particular segment was omitted in the minimal pair (e.g. SO v. OH). All her errors involved sequences of consonants, in particular the contrasts between [sp] and [ps] (e.g. LISP v. LIPS) or [sk] and [ks] (e.g. FLASK v. [flæks]) in word final position. Two metathetic errors were also noted (e.g. TOPIC and [tokɪp] were thought to be the same; [bikut]and [bituk] were thought to be the same). Errors were made on both real and non-word items. Rachel's input sequencing difficulties affect not only the sounds used in the Bridgeman and Snowling (1988) tasks ([st] and [ts]), but also other [s] clusters in word final position such as [sp] and [ps], and [sk] and [ks].

(c) Is there a link between Rachel's spelling and her speech? Is she able to spell words with clusters that she finds hard to produce? How does she cope with non-word spelling tasks that draw heavily on her phonological skills? Rachel was given a series of words with word-initial clusters to spell from dictation (Griffiths, 2002). She was able to write all clusters correctly with the exception of a letter reversal (
 for [dr]) and <sch> for 'sq' in the real words. In the non-word spelling task she made similarly few errors with only <ql> for [kl], and <q> for [skw].' Her errors suggested a lack of orthographic experience, and all her erroneous spellings were logical attempts. There seemed to be no clear link between Rachel's speech and her spelling.

2.3 Speech analysis

PACS (Grunwell, 1985) was used to provide information on Rachel's speech production. A summary of the findings is presented in Table 7.2.

Table 7.2
Summary of Rachel's speech data at CA 7;2

Assessment	Comments	
Severity indices	PCC 96.1% PVC 100% PPC 97.5%	
Phonetic inventory	Word initial position: all phonemes Word medial position: all phonemes Word final position: all phonemes	
Stimulability	All phonemes	
Phonological processes analysis (% use)	Developmental processes: stopping (78%), reduction of [s] clusters (72%)	
Single word speech sample	[tætikɪlə] for CATERPILLAR [hɒsbɪkɪl] for HOSPITAL [pun] for SPOON [kul] for SCHOOL [dɛks] for DESK [dɪdəd] for SCISSORS	[æs] for ASK [æt] for ASK [wɪʔ] for WITH [lit] for LEAF [boɪd] for BOYS
Connected speech sample	[θəmænwəuntbɑɪ.ɪt] for THE MAN WON'T BUY IT [ðɪsmænɪzwɪmɪn] for THIS MAN IS SWIMMING [ɪtwɜgɛərɪ] for IT WERE SCARY [ætkwɪtmɪt] for AT CHRISTMAS	

The severity of Rachel's speech difficulties was estimated at two points before the intervention: at the start of the macro-assessment, and at the micro-assessment, carried out ~6 weeks later. PCC (percentage of consonants correct), PVC (percentage of vowels correct) and PPC (percentage phonemes correct) were used[15]. The difference between these scores at the two pre-intervention points was not a significant one indicating a stable pre-intervention baseline. The severity indices suggest that Rachel's speech difficulties are very mild. Nevertheless, she does have some specific difficulties: Rachel found it hard to produce longer, multisyllabic words. Sequencing errors (e.g. [tætikɪlə] for CATERPILLAR) and other sound confusions (e.g. [hɒsbɪkɪl] for HOSPITAL) were frequently noted in words with 3 or more syllables. Cluster reduction was observed on some occasions but limited only to simplification of [s] clusters. This process occurred both word-initially (e.g. [pun] for

[15] following guidelines from Dodd (1995) and Shriberg et al. (1997c) and discussed in greater detail in Chapter 9 on intelligibility.

SPOON, [kul] for SCHOOL) and word-finally (e.g. [æs] or [æt] for ASK). Cluster reduction of [s] clusters occurred for 72% of possible instances. In the word-final position, she was also frequently noted to include all elements of the [s] cluster but in a reversed order (e.g. [dɛks] for DESK).

Stopping of [s] was a frequent feature of Rachel's speech (e.g. [dɪdəd] for SCISSORS) and occurred in all word positions for approximately 78% of possible instances. Some inconsistent stopping of [θ, f and z] was also noted on occasion (e.g. [wɪʔ] for WITH; [lit] for LEAF, [bɔɪd] for BOYS).

Rachel's difficulty with [s] production both in isolation and in clusters is the most striking aspect of the speech analysis, and one that may affect her intelligibility. The intervention programme focused on [s]. But the question still remained whether to address this phoneme in isolation (with possible generalisation to clusters, or clusters being taught at a later date) or to address [s] clusters in the hope that generalisation to [s] in isolation will occur. This question is considered in greater detail in the micro intervention planning section.

In terms of Dodd's (1995) classification system, Rachel did not meet criteria for inconsistency since she showed only 20% inconsistency in tasks requiring her to name items on more than one occasion over the course of a session. Dodd (1995) and Dodd, Hua, Crosbie, Holm and Ozanne (2002) suggest that 40% or more inconsistent productions are required over the course of a single session in order to consider a child in the inconsistent group. Rachel's oro-motor skills and articulation of individual phonemes are normal. Her phonological errors are all developmental ones expected from a younger child, with no unusual error patterns (Dodd et al., 2002) noted. This cluster of characteristics suggests that she is a child with consistent, delayed speech.

2.4 Child interview and parent / teacher report

This part of the assessment aimed to obtain impressions of Rachel's speech from Rachel herself, her class teacher and parents. As with the other assessments, this information was used to assist with intervention planning and to evaluate the outcome of the intervention.

2.4.1 Child interview

Rachel was interviewed in a semi-structured way with the aim of discovering more about the following areas: (1) her experience of speech and language therapy, (2) her perception and awareness of her own speech, (3) her perceptions of communication more generally, and (4) her attitudes to literacy. This interview procedure was carried out midway through the intervention programme at CA 7;8 when a rapport had been established (see Appendix 3). Rachel was aware of her speech difficulties and acknowledged that [s] was often hard for her to say, as well as [f] and some 'other long words.' She was concerned that she sounded like a younger child and that people would perceive her as 'a baby' because of her speech difficulties. The results of the second interview appears in the evaluation section (Section 6) for comparison. Table 7.3 summarises the main findings of the first interview.

Table 7.3
Summary of findings from Rachel's semi-structured interview carried out midway through intervention at CA 7:8

Area of questioning	Main findings	Examples of Rachel's response
Rachel's experience of SLT • Present	Enjoys therapy a great deal	"it's the best thing I've ever done at school"
	Enjoys all games and likes reading	"I like the games"
	Doesn't enjoy spelling especially doing the lengthy baselines	"don't like … writing everything"
• Past	Remembers previous therapy and therapists well	"was nice"
Rachel's perception and awareness of own speech	She needed to come to speech mainly because of not being able to say 's'	"to help with 's'
	She can do it now	"I can do it now"
	She likes talking both in the classroom and to her friends	
Rachel's perceptions of communication more generally	She enjoys both talking and listening	"talking is nice; listening is nice"
	Most people in England talk the same language but people in other countries talk different languages. She was aware of a child in the school who does not have English as a first language	
Rachel's attitudes to literacy	Reading is easy and fun for her.	"I like reading… reading everywhere "
	Writing is more challenging	"sometimes you can't spell some words… And sometimes you don't do enough"
	Reading and writing are both important for success	"you get clever … and you can get to know more words, and … be right clever"

2.4.2 Teacher report

Rachel's class teacher was unable to complete Bishop's (1998) Children's Communication Checklist due to time constraints. However, informal discussion with Rachel's Year 2 teacher at the start of the project suggested that concerns about Rachel's speech were relatively minor. She was considered to be 'almost always intelligible.' [s] was cited as a problematic sound for Rachel, although the teacher thought that there might be other sounds that were not always clear. Rachel was described as being sensitive about her slightly delayed speech. Her academic abilities were described as excellent and her language – both written and oral – were considered by her teacher to be amongst the best in the class.

In order to provide further information about Rachel's academic progress over the course of intervention, her SATs results were obtained for the assessments carried out prior to intervention (CA 7;3). Rachel obtained 2A for numeracy and 2B for both reading and writing. These scores are discussed in further detail in the evaluation of the intervention.

2.4.3 Parent report

Rachel's parents were concerned about her speech at the start of the project. They acknowledged that she had improved greatly, but were uncertain as to whether this improvement was due to age or because of the speech therapy she had had. They reported that her family and close friends always understand her, and her intelligibility was not a great concern to them. However, they were concerned that she had become increasingly aware of her 'babyish' speech and on several occasions has been upset because she was mistaken for a younger child or misunderstood by strangers. They wanted intervention to improve the clarity of her speech and for her to talk like other children of her age. They had no concerns about Rachel's understanding of language or her more general communicative and academic abilities.

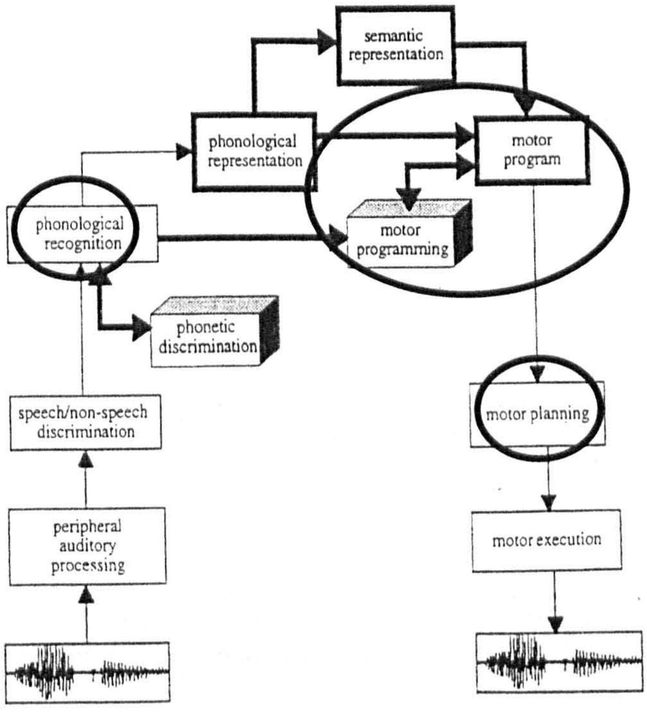
3. MACRO INTERVENTION PLANNING

Intervention planning focused on three main areas with each one serving as a rationale for the work carried out. These included (1) a psycholinguistic rationale which aimed to answer the question: "What aspects of the speech processing profile should be worked on?", (2) a phonological rationale which aimed to answer the question: "Which aspects of the sound system should be targeted, and (3) a more general child-centred rationale which aimed to answer the question: "What other aspects important to the child should be taken into account? Each of these is discussed in the sections that follow.

3.1 Psycholinguistic rationale – What aspects of the speech processing profile should be worked on?

Rachel's main deficits were mapped from the speech processing profile onto the Stackhouse and Wells (1997) speech processing model. Rachel's main areas of deficit are shown in Figure 7.2.

Figure 7.2
Speech Processing Model (from Stackhouse and Wells, 1997) showing Rachel's main areas of difficulty at CA 7;1



Rachel has difficulties with both input and output: phonetic discrimination, stored motor-programmes and her online motor programming and planning skills are all areas that were noted as problematic on her profile and which intervention needed to address. Figure 7.2 shows that phonological recognition is problematic for Rachel as measured by the discrimination tasks (level B and D in Figure 7.1). Her stored knowledge of phonological representations and semantics were relatively good. However, her stored motor programmes and online motor-programming are circled as problematic since her scores on levels G, I and J were lower than her peers in Figure 7.1. Because of the uncertain relationship between input and output, and the likelihood that these deficits have affected Rachel's speech processing in a circular way, *both* input and output were considered as targets, i.e. to work on the speech processing system as a whole (Waters, 2001). Rachel's intervention was required to carefully affect positive change in the areas of weaknesses, using the stronger areas to gentle 'scaffold' the desired change.

One part of Rachel's intervention programme specifically addressed her auditory discrimination skills. Using the strengths of her peripheral auditory processing and her literacy skills, Rachel will be given the opportunity to reflect and discriminate between closely related word pairs. A parallel aim of the programme will be for Rachel to produce words in a carefully supported way. It is hypothesised that Rachel has established inaccurate motor programmes for familiar words, and it is likely to be difficult to modify these habitual patterns immediately. By teaching Rachel *new* words using a multi-faceted approach that taps her strengths of semantic knowledge and literacy, new and accurate motor programs can be built up, and may 'shake-up' the already existing inaccurate programmes. This will also provide Rachel with an opportunity to reflect on her own speech production and to improve her self-monitoring skills (see Fig 7.1, level L). The third aspect of the programme will aim to combine the input and output skills. Rachel will be given opportunities to discriminate between closely related word pairs as well as encouraged to produce stimuli items. Again, many of these words will be unfamiliar to her. Drawing on Rachel's knowledge of written forms as well as her semantic knowledge will support the process of new word learning. Table 7.4 summarises the psycholinguistic targets of intervention.

Table 7.4
Rachel's intervention tasks and each one's psycholinguistic focus

Intervention	Example of tasks	Aspects of speech processing model targeted
Speech treatment	'Meaningful minimal pair therapy' (e.g. following Weiner, 1981)	Mainly targets: motor programming and stored motor programmes. Also involves motor planning at connected speech level.
Auditory discrimination treatment	Listening and posting games (e.g. see Waters, 2001)	Mainly targets: phonological recognition skills
Speech and auditory discrimination treatment	Combination of above tasks	Mainly targets: phonological recognition, motor programming and stored motor programmes.

3.2. Phonological rationale - Which aspects of the sound system should be targeted?
Research has shown that teaching consonant sequences improves singleton production, while the reverse does not seem to occur (Barlow, 2001). In Rachel's case, intervention would be more efficient if it addressed clusters, given that the singleton [s] should then improve too. If [s] was addressed in isolation, it seems unlikely that her [s] cluster production would also improve. Rachel has specific difficulty in discrimination of consonant sequences (rather

than auditory discrimination of single segments) and work on production would then be linked and supported by similar work on auditory discrimination. Research by Gierut (1999) found that treatment of [s] + stop clusters did not promote widespread change across all consonant sequences, while treatment of other consonant sequences did. This suggests that [s] + stop clusters are different to other clusters, and require specific intervention to promote their accurate production. [s] clusters are frequently described as adjuncts: consonants adjoined more loosely to a word than a true cluster (Barlow, 2001; Velleman, 2002). The special status of [s] clusters has been supported by treatment studies which have found that treatment of these adjuncts does not result in generalisation to other clusters (Gierut, 1999). Furthermore, it has been noted that the adjuncts as a group may be acquired before other clusters, or after – but essentially that they can be clearly distinguished as a group from the other clusters.[16]

Research (e.g. Ferguson, 1978; Edwards, 1983; Grunwell, 1985; Redford, MacNeilage and Davis, 1997) has suggested that some phonemes emerge first in word-final position before becoming established in word-initial position, and in other cases the reverse is true. When considering word-position, there is some evidence to suggest that [s] production is easier for children acquiring this phoneme in word final position. Indeed, when gathering baseline data for the intervention it was noted that Rachel was already able to produce [s] as the final segment in some CVC words. However, Rachel found it challenging to discern differences between sounds in the word final position, which may be less acoustically salient than sounds in word initial position. The present intervention programme aimed to address [s] cluster production word finally, and auditory discrimination of these sounds in the word final position since in addition to the reasons outlined above, there are few words in English with reversible [s] clusters word initially (e.g. SPIN -> [psɪn], but NEST -> NETS).

3.3. Child-centred rationale - What other aspects important to the child should be taken into account?

Rachel was becoming increasingly aware of her speech difficulties, and her parents and teacher mentioned that she was sensitive about sounding like a younger child. The intervention programme aimed to build her confidence in terms of her strengths (i.e. her good language and literacy skills). She was motivated to change her speech and could thus be considered as a partner in therapy with the nature and goals of activities made explicit. Rachel was performing well academically and her literacy skills were good for her age.

[16] This chapter refers to [sp], [st] and [sk] as 'clusters', with awareness that the term 'adjunct' may be linguistically more appropriate.

Since her speech difficulties place her at increased risk for experiencing difficulties in these areas (Bishop and Adams, 1990; Bishop and Clarkson, 2003) her progress and skills in these areas should be carefully monitored. She has been resilient in terms of her response to her speech difficulties to date, and this resilience might be investigated further in terms of her learning style and personality as she progresses in therapy.

4. MICRO INTERVENTION PLANNING

Four lists of stimuli were devised, with three treatment lists and seven control lists.

The requirements for each of the ***treatment*** lists were as follows:

(a) Each list consisted of 10 monosyllabic CVCC or CCVCC words. Although CVCC words were preferred, in some cases CCVCCs had to be used. Where this was the case these were balanced across the lists.

(b) Each list represented a different [s] cluster: List A represented the cluster [sp]; list B contained the [st] words, and list C contained the [sk] items. The words had these clusters in the word-final position.

(c) Words were matched across the lists in terms of the Kucera-Francis written frequency (MRC Psycholinguistic database[17]) and for spelling irregularities.

(d) Words familiar to Rachel were preferred, but where this was not possible due to phonetic constraints, familiarity of words was balanced across the three lists. Rachel's familiarity with the words was determined by picture-naming and discussion.

(e) Words which could have the final consonant clusters reversed to yield a real word (e.g. CLASP -> CLAPS) were favoured, although this was not possible for all items.

(f) Each list of words was treated in a different way: List A was randomly selected as the speech-only treatment list. List B was randomly selected as the discrimination-only treatment list, and List C as the discrimination *and* speech treatment list.

The three stimuli lists are presented in Table 7.5

[17] http://www.psy.uwa.edu.au/mrcdatabase/uwa_mrc.htm

Table 7.5
Rachel's stimuli lists for treatment

List A: [sp] Speech treatment	List B: [st] Auditory discrimination treatment	List C: [sk] Auditory discrimination and speech treatment
CLASP	HASTE	RISK
GASP	WEST	DESK
LISP	GUST	DISK
CRISP	BOAST	BRISK
CUSP	JEST	CASK
GRASP	VEST	TASK
RASP	FEAST	FLASK
WASP	ROOST	DUSK
WISP	CRUST	KIOSK
UNCLASP	RUST	TUSK

Each therapy session addressed a subset of the items from each list using the appropriate treatment method. The amount of input for each list was balanced as closely as possible, e.g. if two items from list A (speech treatment) were worked on for 20 minutes in a session, then two items from list B (auditory discrimination treatment) would be worked on for a similar amount of time, and two items from list C (speech and auditory discrimination treatment) were worked on for the same length of time.

The main aim of the intervention was to improve Rachel's speech processing so that she was able to discriminate closely related sounds more accurately, and also to improve the accuracy of her speech production for consonant clusters. The intervention was designed to facilitate these aims, and in addition to allow for comparison in the change brought about for each list. More specific questions that were posed regarding Rachel's intervention included the following:

1. Will the auditory discrimination of [sp] items improve in addition to the targeted aspect of speech?
2. Will the production of [st] words improve in addition to the targeted aspect of auditory discrimination?
3. Will [sk] words improve more readily in terms of both input and output than the other two lists?

In addition to these questions, further questions were asked with regard to generalisation:

(a) This intervention programme was heavily focused on consonant clusters in the word final position. Will there be generalisation to the same clusters in word initial speech production (e.g. <u>SP</u>OON)? Will the frozen motor programmes be updated to more accurate realisations?

(b) Will Rachel's online motor programming and planning improve so that she is able to accurately produce non-words which contain the treated consonant clusters?

(c) Will generalisation extend to other untreated [s] consonant clusters (e.g. [spr], [sn])?

(d) Will singleton [s] production improve as a result of the cluster treatment?

(e) Will production of other problematic fricatives (e.g. [z], [θ] and [ʃ]) improve as a result of the fricative [s] treatment?

(f) Will auditory discrimination of closely related words and non-words improve generally?

(g) Are Rachel's speech difficulties reflected in her spelling? And would improved speech output result in improved written forms?

The seven control stimuli lists were designed in order to answer these questions. These items were not treated in the intervention programme but used as controls to assess change occurring within the speech processing system between pre- and post- intervention phases. The five control wordlists are presented in Table 7.6. As for the stimuli items shown in Table 7.4, these were selected to meet criteria outlined in that section, where possible.

Table 7.6
Rachel's control stimuli for assessment pre- and post-intervention, to be used to answer a range of research questions

Question	Controls items used to answer questions		
(a) Will there be generalisation to the same clusters in word initial speech production?	**[sp]** SPECK SPIKE SPACE SPANNER SPADE SPARK SPOKE SPONGE SPOON SPIDER	**[st]** STEAK STAFF STAR STOOL STAIN STALK STATUE STATION STEAM STEP	**[sk]** SKETCH SKUNK SKI SKIRT SKATE SKELETON SKIN SKINNY SKIP SKITTLE
(b) Will Rachel's online motor programming and planning have improved so that she is able to accurately produce non-words which contain the treated consonant clusters?	**[sp]** [mʊsp] [fɪsp] [pɪsp] [bæsp] [tɛsp] [kasp] [θɑsp] [dʒɒst] [lʊsp] [hɑʊsp]	**[st]** [dɛst] [ɡɛɪst] [nɛʊst] [vɪst] [bɪst] [θæst] [fɛst] [kʊst] [hʊst] [dʒɒst]	**[sk]** [bɒsk] [dæsk] [kɒsk] [maɪsk] [faʊsk] [θɪsk] [dʒɛsk] [lɑsk] [tʃʊsk] [rɛɪsk]
(c) Will generalisation extend to other untreated [s] consonant clusters?	**[sn]** SNORE SNAIL	**[sm]** SMASH SMOKE	**[sl]** SLIME SLIT
	[sw] SWITCH SWAN	**[skw]** SQUIRREL SQUARE	**[str]** STRAWBERRY STRONG
	[scr] SCRATCH SCRUB	**[spl]** SPLIT SPLASH	**[spr]** SPRAY SPRING
(d) Will singleton [s] production improve as a result of the [s] cluster intervention?	**Word initial** SOCK SADDLE SALAD SEAL SALT SARDINE SAW SECOND SINGER SOAP SAUSAGE	**Within word** PERSON ASSEMBLY BASKET BISCUIT PLASTER MONSTER ANSWER FATSO ASTHMA BASIN WHISPER CASPER MUSCLE SAUSAGE	**Word final** CASE MOUSE CROSS ADDRESS CLASS GRASS OCTOPUS TENNIS PALACE CIRCUS
(e) Will production of other fricatives improve as a result of the fricative [s] treatment?	**[z]** **Word initial** ZOO ZEBRA ZED ZERO ZIP **Within word** MUSIC EASEL POISON PIZZA RAISIN DAISY PUZZLE BLAZER PRISON COUSIN **Word final** MAY'S MAZE	**[θ]** **Word initial** THIEF THIN **Within word** TOOTHBRUSH TOOTHPASTE **Word final** MOTH TEETH	**[f]** **Word final** LEAF ROOF GIRAFFE CALF KNIFE

Table 7.6 *cont.* Rachel's control stimuli

	SIZE SIGHS BANANAS ROSE BUZZ LAZE LAYS BRUISE		
(f) Will auditory discrimination of closely related non-words improve generally?	[sp] [hʊsp] [hʊps] [dʒæsp] [dʒæps] [vʊsp] [vʊps] [bɛsp] [bɛps] [tisp] [tips] [kɜsp] [kɜps] [mɑsp] [mɑps] [θɒsp] [θɒps] [wɔɪsp] [wɔɪps] [rɒsp] [rɒps]	[st] [dɪst] [dɪts] [dʒeɪst] [dʒeɪts] [kɛst] [kɛts] [fɒst] [fɒts] [bleɪts] [bleɪst] [nust] [nuts] [θʊst] [θʊts] [lɒst] [lɒts] [hɛst] [hɛts] [bɪst] [bɪts]	[sk] [gɒsk] [gɒks] [fisk] [fiks] [mɛsk] [mɛks] [pusk] [puks] [disk] [diks] [tʃɑsk] [tʃɑks] [laʊsk] [laʊks] [waɪsk] [waɪks] [hɛsk] [hɛks] [taʊsk] [taʊks]
(g) Are Rachel's speech difficulties reflected in her spelling? And would improved speech output result in improved written forms?	Control items from (a), (c), (d) and (e) above		

For each of the treatment stimuli lists and the control stimuli, Rachel was required to carry out the following tasks:

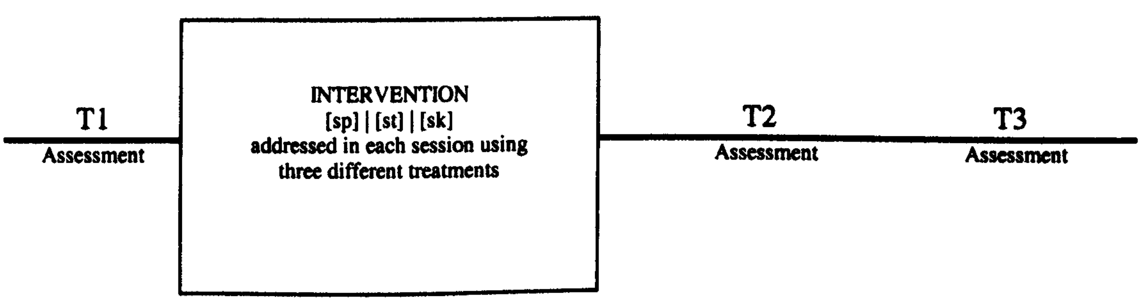
(a) picture naming, where the word was real and familiar to Rachel, and / or repetition for unfamiliar words
(b) spelling of the item to dictation and with picture support where possible
(c) auditory discrimination of non-word minimal pairs using a same different paradigm, e.g. are these the same [hʊsp] / [hʊps]?

These measures constituted the micro evaluation, which was carried out at three points in the study:

- T1: pre-intervention when Rachel was CA 7;2-7;3
- T2: post-intervention at short-term follow-up when Rachel was CA 7;8
- T3: post-intervention at long-term follow-up when Rachel was CA 8;10.

Figure 7.3 shows the design of the intervention.

Figure 7.3
The design of Rachel's intervention programme



5. INTERVENTION

5.1 Overview of intervention

Rachel received a total of 10 hours of intervention: ten sessions of 1 hour each. Each session involved work on three [s] + stop clusters in the word-final position. Each cluster was associated with a different treatment, i.e. [sp] was given speech-only treatment; [st] was given an auditory discrimination treatment, and [sk] received treatment addressing both input and output. Reading and writing were used in all the interventions. Rachel was seen on a twice-weekly basis in school. Sessions were carried out in a quiet room with only the therapist and Rachel present. Each session was structured so that equal amounts of time were spent on each of the three wordlists, and the same number of words were addressed from each list at each session. Rachel was 7;7 at the start of the intervention itself and was 7;11 on completion of the final intervention session.

5.2 Intervention report

Each session aimed to work on a subset of speech items (list A, Table 7.5), a subset of items from the auditory discrimination list (list B, Table 7.5) and a subset of items from the speech and discrimination list (list C, Table 7.5). The therapist aimed to spend equal amounts of time on each of the lists, and from session to session the order of activities used to target each list was varied. Table 7.7 presents a summary of the sessions carried out together with comments on Rachel's progress and an indication of the type of activities carried out in each session.

Table 7.7
Summary of Rachel's intervention sessions

Session no.	Targets List A words: speech treatment List B words: auditory discrimination treatment List C words: speech and discrimination treatment	Comments
1	A: CLASP; UNCLASP	Spoke about these new words: Rachel preferred to use 'grab' and needed to be encouraged to say the correct targets initially. Many reversals were noted (e.g. [klæps] for CLASP). Spelling was used to support these attempts by placing these on the table while saying the words.
	B: HASTE; RUST	Rachel found these auditory discrimination tasks relatively easy, although initially hesitant with HASTE/HATES.
	C: RISK; TUSK	The same activities used for lists A and B were combined with the list C items. The spelling activity assisted Rachel with her speech production. She is confident about her writing. Speech production of RISK was excellent, but she found TUSK harder and persisted with saying [tuk.sk]. Rachel had to say either RISK or RICK'S and I would point to the item in question. She scolded me for making some mistakes, even though I was doing exactly what she had said: her representations are accurate.
2	A: WASP, CRISP	Rachel found speech production of these items hard. Spelling helps a great deal and she uses this effectively as a support.
	B: WEST, BOAST	Rachel did well with the auditory discrimination tasks and needed minimal support to perform the listening tasks required of her.

Table 7.7 *cont.* Summary of Rachel's intervention sessions

	C: DUSK, FLASK	Her auditory discrimination was excellent but her speech production was inconsistent.
3	A: WISP, LISP	Rachel learnt these unfamiliar words quickly and was soon able to use them appropriately in sentences. Speech production was carried out using letters on the table to physically mark out the difference and what the sequence of phonemes should be. I encouraged her to use a less exaggerated [s] now but she found this very hard. It seems to be the swift change from 's' to 'p' that is challenging for her.
	B: CRUST, JEST	Rachel needed encouragement to make accurate distinctions but was soon doing so with ease. She has improved in her ability to discriminate these similar sounds – will this improvement cross over into her speech at some point?
	C: BRISK, DESK	Rachel did not know what a desk is. Good auditory discrimination following practise but finding speech much more challenging. She tries very hard and concentrates well in the sessions.
4	A: GASP, CUSP	Rachel found these words hard to remember and use. We played a 'barrier' game which involved giving instructions from behind a screen. We both got confused! Using written letters as cues afterwards was a great help. Rachel then attempted the words without the cues, and was able to do this with careful planning. Her confusion with the order of those final sounds was evident as she spent a long time thinking about the spellings.
	B: GUST, VEST	Continues to do well with this type of task – she is quite enjoying this now whereas she found it hard. She said that she finds it easy because she imagines a VEST and then she imagines VETS. This indicates her top-down semantic strengths and why the non-word tasks are harder for her.
	C: TASK, DISK	These words were incorporated into relevant activities as appropriate.
5	A: GRASP, RASP	As expected, Rachel finds the vocabulary challenging. The clusters remain hard unless [s] is prolonged. However, have noted that she is getting [s] as a singleton more frequently in SIWI and SFWF positions.
	B: FEAST, ROOST	We played an active game today which involved jumping on squares of paper around the room depending on whether sounds were the same or different. Rachel performed well on the task, achieving 100% success.
	C: KIOSK, CASK	Again, the new vocabulary is challenging for Rachel but she did well and achieved some success.
6	A: whole list	Revision of all 10 words. Rachel was able to remember 8/10 words and their meanings. She had difficulty in saying all the words correctly, but is able to order the sounds in an appropriate sequence by using written letter cues. Her [s] production has improved a great deal.
	B: whole list	Rachel has done very well with the auditory discrimination activities, achieving an average of 80% correct discriminations. She has moved from hesitant responses to more confident judgements.
	C: whole list	More new words have been learnt in this category. The discrimination of these words is much easier for Rachel than the production of the words but she has tried hard and seems to have increased awareness of the importance of sequencing consonants.
7	A: LISP, WISP, CRISP, WASP, GASP	Review of the speech targets following the school holidays. Rachel had managed to remember the words and was able to say all words in this list correctly. She was not needing to lengthen the 's' as we were doing previously. Perhaps she needed the break to consolidate her skills.
	B: VEST, JEST, CRUST, GUST, FEAST	Reviewed the meanings of these words and then played a game with Rachel listening to my speech and deciding if the pronunciation was accurate. Rachel made only three errors in total (~80% correct). We tried listening with a speech amplifier and she said it was easier.
	C: TASK, FLASK, DISK, KIOSK, TUSK	Comments as above apply to these words: Rachel has remembered most of the words and could produce them accurately. She could not remember meanings of DISK and KIOSK, and also found these the hardest words to say.
8	A: CLASP, CUSP, GRASP, RASP, UNCLASP	Today we used the computer. Rachel made sentences and found pictures for each of the targets. She named words in isolation as well as in sentences, and said it was easy for her to do. She achieved ~80% correct for both single word speech production and connected speech.
	B: HASTE, WEST, BOAST, ROOST, RUST	Rachel used the mouse to click on target words and foils. I said the words and she was required to group them into [st] and [ts] categories. We tried with her looking at the spelling, and then not looking and just listening. She achieved 100% accuracy.
	C: RISK, DESK, BRISK, CASK, DUSK	Words in this list were included in both games described for A (speech) and B (auditory discrimination) above. She did well with both activities although BRISK was hard for her to say and discriminate from BRICKS. This may be because of phonological complexity (clusters WI and WF) and difficult meaning.

Table 7.7 *cont.* **Summary of Rachel's intervention sessions**

9	A: LISP, WISP, CRISP, WASP, GASP	Another computer session today, focusing on a story written using the target words. Rachel filled in the missing words and produced these both as single words an in sentences. The task became more challenging for her with the sentences.
	B: VEST, JEST, CRUST, GUST, FEAST	Focused on auditory discrimination questions linked to the story. Rachel obtained 100%.
	C: TASK, FLASK, DISK, KIOSK, TUSK	These words were incorporated in both activities described above. Excellent speech production in single words; slightly more challenging in sentences. Rachel says that KIOSK is the hardest word to say and write.
10	A: CLASP, UNCLASP, CUSP, GRASP, RASP	Revision of story from previous session followed by revision of all other words from this list. Noted reduction of one word initial [sp] cluster in the story.
	B: HASTE, RUST, WEST, BOAST, ROOST	Revision of auditory discrimination items from previous session and linked to story. No difficulties noted.
	C: RISK, DUSK, BRISK, DESK, CASK	Revision of items from previous session. Coped well with remaining items in terms of both input and output tasks.

6. EVALUATION

This section focuses on the outcome of Rachel's intervention programme. Section 6.1. is a micro evaluation of the intervention study and aims to look at the specific changes in treated stimuli and untreated control items outlined in Section 4. The section starts with an overview of the micro evaluation (6.1.1), before considering speech (6.1.2), spelling (6.1.3) and auditory discrimination (6.1.4) in turn. Section 6.15 summarises the findings from the micro evaluation. Section 6.2 provides a macro analysis of the intervention, aiming to outline broader benefits in the following areas: Standardised language assessment (6.2.1), speech profiling in a psycholinguistic framework (6.2.2), speech analysis (6.2.3), and the child interview and parent / teacher report (6.2.4).

6.1. Micro evaluation

Rachel was reassessed at three intervals during the intervention study: pre-intervention at CA 7;1, and following 10 hours of intervention which took place twice-weekly over the course of 2 – 3 months. The post-intervention evaluations took place at T2 when Rachel was 7;8 and at T3 when she was 8;10. The micro evaluation involved the following tasks:

(a) picture naming, where the word was real and familiar to Rachel, and / or repetition for unfamiliar words
(b) spelling of the item to dictation and with picture support where possible
(c) auditory discrimination of non-word minimal pairs using a same different paradigm, e.g. are these the same [hʊsp] / [hʊps]?

The results for these assessments are described below.

6.1.1 Overview

Table 7.8 gives an overview of Rachel's progress on treated and untreated stimuli by comparing the percentage of target phonemes correct in her speech, spelling and auditory discrimination at pre-intervention assessment (T1) with scores obtained on completion of the programme at T2 (short-term follow-up), and at T3 (long-term follow-up). The scoring procedure focussed specifically on the target clusters, not on the remainder of the word. One point was awarded for each correct target cluster (i.e. [sp], [st] and [sk]). Raw scores were converted into percentage. The data for the untreated stimuli in Table 7.8 are limited to the words with the clusters in the word-initial position and for the non-words with the clusters in word-final position.

Table 7.8
Overview of Rachel's performance in speech, spelling and auditory discrimination

	T1 Pre-intervention % of target phonemes correct**		T2 Post-intervention % of target phonemes correct**		T3 Post-intervention % of target phonemes correct**	
	Treated stimuli	Untreated controls	Treated stimuli	Untreated controls	Treated stimuli	Untreated controls
Speech: *(mean)*	*(13.3)*	*(16.6)*	*(93.3)**	*(81.6)**	*(93.3)**	*(95)*,+*
[sp]	0	5	80*	95*	100*	100*
[st]	30	45	100*	55	90*	90*, +
[sk]	10	5	100*	95*	90*	95*
Spelling: *(mean)*	*(36.6)*	*(75)*	*(96.6)**	*(88.3)*	*(86.6)**	*(85)*
[sp]	10	80	100*	95	80*	95
[st]	80	80	90	90	90	75
[sk]	20	65	100*	80	90*	85
Auditory discrimination: *(mean)*		*(43.3)*		*(63.3)*		*(86.6)*+*
[sp]		20		80*		100*
[st]		40		70		90*
[sk]		70		40		70

** The scoring procedure focussed specifically on the target clusters, not on the remainder of the word. One point was awarded for each correct target cluster (i.e. [sp], [st] and [sk]). Raw scores were converted into %.
* paired with T1 results ($p<.05$)
\+ paired with T2 results ($p<.05$)

A two-way mixed between-within subjects ANOVA was conducted. There was a statistically significant main effect for time for both speech [$F(2, 87) = 60.348$, $p< .001$] and spelling [$F(2, 87) = 20.107$, $p< .001$]. Both Rachel's written and spoken production of the targeted clusters had changed over the course of the intervention programme. The effect size for speech (eta squared = .581) was slightly greater than that for spelling (eta squared = .316), but both are large effects (Cohen, 1988).

Paired samples t-tests were carried out to compare performance on stimuli lists at two points in time. In terms of speech, it was found that Rachel's production of the treated stimuli had improved significantly from T1 to T2 (t(29)=-5.385, p<.001) and from T1 to T3 (t (29) = -5.592, p<.05), although not from T2 to T3 after intervention ceased. For the untreated items, significant improvements were noted when comparing T1 with T2 (t(79) = -4.222, p<.05), and T2 with T3 (t(79) = -3.414, p<.05) showing that overall the intervention was effective and that the greatest gains were made after intervention had ceased, between the follow-ups.

In terms of speech production for individual phonemes, it can be seen that Rachel's production of [sp] and [sk] changed significantly from T1 to T2 (t(9)=-6, p<.001), and from T1 to T3, with no further gains noted between T2 and T3 after intervention had ceased. The treated [st] words responded in a similar way to the other two clusters, with significant gains made from T1 to T2 (t(9)=-4.583, p=.001) and when comparing scores at T1 with those at T3 (t(9)=-2.714, p<.05). The untreated [st] words were slower in their generalisation response to treatment: no significant gains were noted from scores at T1 to T2, but significant improvement was noted from T2 to T3 (t(19)=-3.199, p=.005) and when comparing T1 and T3 (t(19)=-3.943, p=.001).

Rachel's spelling of the treated words improved significantly from T1 to T2 (t (29) =-6.595, p<.005), and T1 to T3 (t (29) =-4.785, p<.005), with no significant changes occurring between T2 and T3. This suggests that the intervention was effective in bringing about improvements in the accuracy of her written representations. For individual clusters it can be seen (as indicated by the * in Table 7.8) that [sp] and [sk] improved significantly from T1 to T2 (t(9)=-6.0, p<.001) and from T1 to T3 (t(9)=-4.583, p=.001). No significant changes were noted across intervention for the [st] items in terms of spelling. Further, no significant changes were noted for the untreated spelling items across these measurement intervals, but Rachel's spelling of the untreated items at T1 was significantly better than her spelling of the treatment words (t(52)=-3.624, p=.001) which meant that there was less scope for further gains with this set.

Results for auditory discrimination revealed significant improvements overall for the three cluster groups when comparing T1 and T3 scores (t(29)=-4.709, p<.001). Auditory discrimination improved slowly with no significant increase noted from T1 to T2, but significant gains made from T2 to T3 (t(29) =-2.971, p<.05). In terms of the individual clusters, there was no significant change noted for Rachel's auditory discrimination of [sk] across the intervention. [sk] words received the combined speech and auditory discrimination intervention. Discrimination of [sp] improved significantly from T1 to T2 (t(9)=-3.674, p=.005) and from T1 to T3 (t(9)=-6, p<.001). [sp] words received the speech treatment only, without discrimination being specifically addressed. Discrimination of [st] improved overall when comparing T1 and T3 scores (t(9)=-3, p<.05). [st] words received the auditory discrimination treatment. The following sections provide more details of these speech, spelling and auditory discrimination results.

6.1.2 Speech

In the micro evaluation, treated and untreated speech stimuli were presented to Rachel in a randomised order. She was asked to name the pictures and repeat the therapist's spoken production of the words. The results presented below focus on single word naming since no significant differences were noted between her naming and repetition of single words. Results are presented in Tables 7.9 – 7.17 below. Table 7.9 compares Rachel's naming of treated [s] cluster words pre-intervention (T1) and post-intervention at T2 at T3.

Table 7.9
Overview of Rachel's production of treated words pre- and post-intervention.

	T1 Pre-intervention % of target clusters correct*	T2 Post-intervention % of target clusters correct*	T3 Post-Intervention % of target clusters correct*
List A: [sp] speech treatment	0	80+	100+
List B: [st] Auditory discrimination treatment	30	100+	90+
List C: [sk] Speech and auditory discrimination treatment	0	100+	90+

* Words were scored correct where [sp], [sk] or [st] was present, and incorrect where [sp], [sk] or [st] was omitted, reduced or transposed.
+ paired with T1 results (p<.05)

Rachel received three different interventions for each of the three word lists. There was not a significantly different response to the three treatments in terms of her speech production. At T2 (and T3) following the completion of intervention, Rachel had made significant gains for each of the three lists. List B ([st] words) received the auditory discrimination treatment only and still showed significant gains in terms of speech production, suggesting that it did not make a difference whether or not speech production was directly targeted.

Table 7.10 provides a qualitative view of changes within each of the treated lists.

Table 7.10
Individual item comparison of Rachel's production of treated words pre- and post-intervention with shaded items showing correct productions

	Stimuli	T1 Pre-intervention	T2 Post-intervention
List A: speech treatment	CLASP	[klæps]	[klæpʔ]
	GASP	[gæps]	[gæsp]
	LISP	[lɪps]	[lɪsp]
	CRISP	[krɪps]	[klɪsp]
	CUSP	[kʌs]	[kʌsp]
	GRASP	[græs]	[glæps]
	RASP	[ræps]	[ræsp]
	WASP	[waps]	[wasp]
	WISP	[wɪst]	[wɪsp]
	UNCLASP	[ʌnklæps]	[ʌnklæsp]
List B: Auditory discrimination treatment	HASTE	[heɪs]	[heɪst]
	WEST	[wɛs]	[west]
	GUST	[gʌst]	[gʌst]
	BOAST	[bəʊs]	[bəust]
	JEST	[dʒɛsp]	[dʒɛst]
	VEST	[vɛs]	[vest]
	FEAST	[fit]	[fist]
	ROOST	[rust]	[rust]
	CRUST	[krʌst]	[klʌst]
	RUST	[rʌt]	[rʌst]
List C: Speech and auditory discrimination Treatment	RISK	[rɪks]	[rɪsk]
	DESK	[dɛkθ]	[dɛsk]
	DISK	[dɪks]	[dɪsk]
	BRISK	[brɪks]	[brɪsk]
	CASK	[kæsθ]	[kæsk]
	TASK	[tæks]	[tæsk]
	FLASK	[flæks]	[flæsk]
	DUSK	[dʊk]	[dʌsk]
	KIOSK	[kɪ.ɒs]	[kɪ.ɒsk]
	TUSK	[tʊks]	[tʌsk]

In the pre-intervention phase, Rachel typically transposed the final consonants (e.g. producing [klæps] for CLASP) finding it hard to sequence them appropriately. In other cases she omitted the final stop consonants (e.g. [kʌs] for CUSP) or, more rarely the [s] (e.g. [fit] for feast). As Rachel was introduced to the new words and encouraged to produce these, she devised online motor programmes for their production. Without support these were produced incorrectly, but when supported with the various techniques used in therapy (e.g. slowed speech, spelling), she was able to produce the words correctly. Therapy helped her to build the correct motor programmes. Through repetition and practise of the words she was able to consolidate the correct programmes that became increasingly more automatic.

Not all of the words were new to Rachel. For the familiar words she most likely had accurate phonological representations and good semantic knowledge. The process of producing the words carefully in therapy sessions aimed to revise and re-formulate the old, inaccurate motor programmes. No difference in Rachel's production of the familiar and un-familiar items was noted. Rachel benefited readily from her own written cues which suggests that she either had existing, accurate orthographic representations on which she could draw, or that she was able to build up orthographic representations with relative ease and has accurate online phoneme-grapheme conversion skills.

It was noted that post-intervention at both T2 and T3 assessments, Rachel was, on some occasions substituting [l] for [r] (e.g. [glæps] for GRASP and [klɪsp] for CRISP. This was also noted in her spontaneous speech at the follow-up assessments, and had not been noted before this time. A possible explanation for this is that Rachel had become very aware of her cluster production as a result of the intervention and was now testing out alternative patterns of cluster sequences.

Untreated speech controls were included in order to answer a range of questions about Rachel's speech. Rachel's spoken production of each category of control items is considered below, by returning to the questions posed previously in Table 7.6.

(a) Will there be generalisation to the same clusters in word initial speech production?

Intervention focused on three specific clusters, [sp], [st] and [sk] in the word final position. The production of these clusters in word final position improved significantly over the course of intervention. Were these gains specific to these clusters in word final position or would an improvement in the same clusters in word initial position also be noted? Control items in this group consisted of CCVC words with [sp], [st] and [sk] word initially in words such as STAFF and SKIRT. Results are presented in Table 7.11 with percentage scores indicating the proportion of single words that were named correctly.

Table 7.11
Rachel's production of untreated control words pre- and post-intervention: [sp], [st] and [sk] in word initial position

	T1 Pre-Intervention+ % clusters correct	T2 Post-intervention+ % clusters correct	T3 Post-intervention+ % clusters correct
[sp] e.g. SPOT	30	100	100
[st] e.g. STAFF	80	30	80
[sk] e.g. SKIRT	20	90	90

+ Words were scored correct where [sp], [sk] or [st] was present, and incorrect where [sp], [sk] or [st] was omitted, reduced or transposed.

Rachel initially found [sp] and [sk] hard to produce, but at the post-intervention assessments, her performance on the naming task had improved significantly and was approaching ceiling ($t(9)=-4.583$, $p=.001$). She was able to generalise from the clusters targeted in word final position in therapy to untreated items, where the clusters appeared in a different word position. In general, research suggests that such generalisation from a phoneme treated in one word-position to another word-position can occur (e.g. Elbert and McReynolds, 1975). However, the question has not been specifically investigated for clusters.

The results for [st] are less clear-cut. Rachel was relatively successful at the baseline phase in that she managed to produce 80% of these clusters correctly in the word initial position. Indeed, returning to the baseline measures for the word-final clusters (shown in Table 7.9), Rachel showed relative strengths with [st], obtaining 30% correct as opposed to 0% for the other two lists. Thus, for Rachel [st] may have been an emerging cluster more well established in her phonological system in terms of productive phonological knowledge. There is no evidence in the literature to support the early emergence of [st] before the other [s]+ stop clusters. There is some evidence that [sk] may be slightly later acquired on average, when compared to [sp] and [st] but no evidence that specifically suggests that [st] is more advanced than the other two (Mcleod et al., 1997).

Rachel's performance with [st] in word initial position declined significantly from 80% (at T1) to 30% (at T2) ($t(9)=4.583$, $p=.001$) rather than improving as one might expect. One possible explanation for this decline is that the words in the [st] list received the auditory discrimination treatment. Direct speech work on [s] clusters in final position may improve motor-programming skills to such an extent that generalisation occurs to other untreated words and all word positions. Auditory discrimination of final sound sequences may improve awareness of the particular sounds, but this does not generalise to motor-programming and have the same sort of generalisation effect noted for the direct speech work. The emphasis on input may have caused confusion with the already emerging [st] in the output motor-programmer. Rachel was not given opportunities to produce [st] words in intervention and this may have affected her motor programming skills for this cluster. The final re-assessment result at T3 supports this theory: At T3 her accuracy of [st] production had returned to 80% suggesting that the intervention itself had a detrimental, rather than a positive effect on this particular subset of control items.

Table 7.12 provides an individual item comparison of the control words with the clusters in word-initial position at T1, T2 and T3.

Table 7.12
Individual item comparison of Rachel's production of untreated control words pre- and post-intervention. Shaded items had the [s] clusters accurately realised.

		T1 Pre-intervention	T2 Post-intervention	T3 Post-intervention
List A: [sp]	SPECK	[pɛk]	[spɛk]	[spɛk]
	SPIKE	[spaɪk]	[spaɪk]	[spaɪk]
	SPACE	[speɪʃ]	[speɪʃ]	[speɪs]
	SPANNER	[pænə]	[spænə]	[spænə]
	SPADE	[peɪd]	[speɪd]	[speɪd]
	SPARK	[pɑk]	[spɑk]	[spɑk]
	SPOKE	[pəuk]	[spəuk]	[spəuk]
	SPONGE	[spʊndʒ]	[spʊndʒ]	[spʊndʒ]
	SPOON	[pʊn]	[spʊn]	[spʊn]
	SPIDER	[paɪdə]	[spaɪdə]	[spaɪdə]
List B: [st]	STEAK	[steɪk]	[seɪk]	[steɪk]
	STAFF	[sɑf]	[stæf]	[stɑf]
	STAR	[stɑ]	[stɑ]	[stɑ]
	STOOL	[stul]	[sul]	[sul]
	STAIN	[steɪn]	[seɪn]	[sleɪn]
	STALK	[sɔk]	[sɔk]	[stɔk]
	STATUE	[stætʃu]	[sætʃu]	[stætʃu]
	STATION	[steɪʃɪn]	[steɪʃɪn]	[steɪʃɪn]
	STEAM	[stim]	[sim]	[stim]
	STEP	[stɛp]	[sɛp]	[stɛp]
List C: [sk]	SKETCH	[kɛtʃ]	[skɛtʃ]	[skɛtʃ]
	SKUNK	[kʌnk]	[sʌŋk]	[sʌŋk]
	SKI	[kɪ]	[ski]	[ski]
	SKIRT	[kɜt]	[skɜt]	[skɜt]
	SKATE	[keɪt]	[skeɪt]	[skeɪt]
	SKELETON	[skɛlətɪn]	[skɛlətɪn]	[skɛlətɪn]
	SKIN	[kɪn]	[skɪn]	[skɪn]
	SKINNY	[kɪnɪ]	[skɪnɪ]	[skɪnɪ]
	SKIP	[kɪp]	[skɪp]	[skɪp]
	SKITTLE	[skɪpɪl]	[skɪtɪl]	[skɪtɪl]

Before intervention Rachel reduced [sp] clusters to [p], and [sk] clusters to [k], e.g. SPECK was produced as [pɛk]; SKI produced as [kɪ]. Post-intervention she was able to produce the entire cluster correctly. When considering Rachel's poor performance with [st] at T2, it was noted that the cluster reduction is of the sort ([st -> s]). In normal phonological development, [s]+ stop clusters are typically reduced to the most salient element with [s] typically *omitted* in the word initial position (Ohala, 1999) in accordance with what is known about the sonority of the phonemes involved. Thus, while this was the case for the errors reported for the [sk] and [sp] lists (word finally and word-initially), Rachel's error pattern for [st] was atypical. Her awareness may have been focussed on [s] as a common feature in all three treatment lists, and thus it had become the most salient aspect for her. Alternatively, sonority sequencing principles suggest that final stop elements would be omitted in word final [s] + stop clusters, and this was the pattern observed in Rachel's errors for the clusters word-finally. It may be that the emphasis of intervention on final clusters was causing confusion when she came to realise the same clusters word-initially. She may have retained the [s] as the most salient element from the word-final work.

(b) Will Rachel's online motor programming and planning have improved so that she is able to accurately produce non-words that contain the treated consonant clusters?

It was hypothesised that the intervention would result not only in Rachel's existing motor programmes being revised, but that the online motor programmer would be altered to allow for more complete and accurate sequencing of clusters. This notion was tested by giving Rachel unfamiliar words to repeat. These non-words contained [s] clusters in word final position such as [mʊsp]. Using non-words ensured that Rachel had not previously encountered the words. The results are presented in Table 7.13.

Table 7.13
Rachel's production of untreated control words pre- and post-intervention: [sp], [st] and [sk] in non-words

	T1 Pre-intervention % clusters correct+	T2 Post-intervention % clusters correct+	T3 Pre-intervention % clusters correct+
[sp] e.g. [mʊsp]	0	100	100
[st] e.g. [vist]	10	80	100
[sk] e.g. [kɔsk]	0	100	100

+ Words were scored correct where [sp], [sk] or [st] was present, and incorrect where [sp], [sk] or [st] was omitted, reduced or transposed.

Results from these control items show that initially Rachel found the non-words hard to produce. At both T2 and T3 assessments following intervention she was able to produce the non-words in a way which showed a significant improvement for each wordlist. This demonstrates the generalisation that occurred as a result of the intervention, and supports the original idea behind the intervention plan: the intervention aimed to not only update the frozen motor programmes of familiar words but also give Rachel the tools to create new and accurate motor programmes. There was no difference in the progress made for the three wordlists despite the different nature of the interventions.

Table 7.14 offers a qualitative perspective on changes within each of the non-word lists.

Table 7.14
Individual item comparison of Rachel's production of untreated control non-words pre- and post-intervention. Shaded items had the [s] clusters accurately realised

	Untreated control non-word	T1 Pre-intervention	T2 Post-intervention	T3 Post-intervention
List A: sp	[mʌsp]	[mʌpts]	[mʌsp]	[mʌsp]
	[fɪsp]	[fɪps]	[fɪsp]	[fɪsp]
	[pisp]	[pips]	[pisp]	[pisp]
	[bæsp]	[bæpst]	[bæsp]	[bæsp]
	[tɛsp]	[tɛps]	[tɛsp]	[tɛsp]
	[kɑsp]	[kɑpsθ]	[kɑsp]	[kɑsp]
	[θɒsp]	[θɒpst]	[θɒsp]	[θɒsp]
	[tʃɒɪsp]	[tʃɒɪs]	[tʃɒɪsp]	[tʃɒɪsp]
	[lusp]	[lups]	[lusp]	[lusp]
	[haʊsp]	[haʊs]	[haʊsp]	[haʊsp]
List B: st	[dɜst]	[dɜθt]	[dɜst]	[dɜst]
	[geɪst]	[geɪs]	[geɪs]	[geɪst]
	[nəʊst]	[nəʊt]	[nəʊs]	[nəʊst]
	[vist]	[fist]	[vist]	[vist]
	[bɪst]	[pɪs]	[bɪst]	[bɪst]
	[θæst]	[θæs]	[θæst]	[θæst]
	[fɛst]	[fɛts]	[fɛst]	[fɛst]
	[kust]	[kuts]	[kust]	[kust]
	[hʌst]	[hʌts]	[hʌst]	[hʌst]
	[dʒɒst]	[dʒɒts]	[dʒɒst]	[dʒɒst]
List C: sk	[bɒsk]	[bɒks]	[bɒsk]	[bɒsk]
	[dæsk]	[dæks]	[dæsk]	[dæsk]
	[kɔsk]	[kɔs]	[kɔsk]	[kɔsk]
	[maɪsk]	[maɪks]	[maɪsk]	[maɪsk]
	[faʊsk]	[fɒks]	[faʊsk]	[faʊsk]
	[θɪsk]	[θɪks]	[θɪsk]	[θɪsk]
	[dʒɛsk]	[dʒɛ]	[dʒɛsk]	[dʒɛsk]
	[lɑsk]	[[lɑt]	[lɑsk]	[lɑsk]
	[tʃʌsk]	[dʒʌk]	[tʃʌsk]	[tʃʌsk]
	[reɪsk]	[reɪs]	[reɪsk]	[reɪsk]

At T1 Rachel typically reversed the word-final clusters (e.g. [fɪps] for [fɪsp] or omitted the final stop element (e.g. [kɔs] for [kɔsk]). At T2 and T3 she had not only progressed to produce all the necessary cluster elements, but was also able to appropriately sequence these.

(c) Will generalisation extend to other untreated [s] consonant clusters?

At the initial assessment Rachel was able to accurately produce most consonant clusters, with the exception of [s] clusters. Rachel's intervention programme focussed on intervention of three [s] clusters ([sp], [st], [sk]), which seemed to be particularly difficult for her. One of the initial questions posed was whether treating three specific clusters would result in improvement of the other problematic [s] clusters. The results are summarised in Table 7.15, and discussed in further detail below.

Table 7.15
Rachel's production of untreated control words pre- and post-intervention: untreated [s] clusters in word-initial position

	T1 Pre-Intervention+		T2 and T3 Post-Intervention+	
	Items correct (n=2)	Examples	Items correct (n=2)	Examples
[sn]: SNORE, SNAIL	2	[snɔ], [sneɪjɪl]	2	[snɔ], [sneɪl]
[sm]: SMASH, SMOKE	2	[smæʃ], [sməʊk]	2	[smæʃ], [sməʊk]
[sl]: SLIME, SLIT	2	[slaɪm], [slɪt]	2	[slaɪm], [slɪt]
[sw]: SWITCH, SWAN	2	[swɪtʃ], [swæn]	2	[swɪtʃ], [swæn]
[skw]: SQUIRREL, SQUARE	0	[kwɪrɪl], [kwɛə]	2	[skwɪrɪl], [skwɛə]
[str]: STRAWBERRY, STRONG	0	[trɔberi], [tərɒŋ]	2	[strɔbɛli], [strɒŋg]
[skr]: SCRATCH, SCRUB	0	[kræʈʃ], [krʊb]	1	[sklæʈʃ], [skrʊb]
[spl]: SPLIT, SPLASH	1	[plɪt], [splæʃ]	2	[splɪt], [splæʃ]
[spr]: SPRAY, SPRING	1	[preɪ], [sprɪŋ]	0	[spleɪ], [splɪŋ]

+ Words were scored correct where [s] clusters was present, and incorrect where cluster was omitted, reduced or transposed.

Initially Rachel was able to accurately produce the 2 element [s] clusters, i.e. [sn], [sm], [sl], and [sw]); thus the intervention had little impact on these clusters, except perhaps to consolidate them at a conversational level. Three part [s] clusters (e.g. [skw], [str], [skr], [spl], [spr]) proved more troublesome for Rachel in the pre-intervention phase. These improved following the intervention, with Rachel being able to realise all three parts of these clusters in most cases. In general, it was interesting to note that the specific word final [sp], [sk] and [st] treatment had positive effects on the more complex 3 part clusters used word-initially. [skr] and [spr] remained challenging for her. Pre-intervention, Rachel had typically omitted [s] from her cluster realisations. Post-intervention she was able to produce [s] accurately and in the appropriate order for most of these untreated [s] clusters.

At T2 and T3 assessment Rachel sometimes substituted [l] for [r] for some of these clusters, e.g. [sklætʃ] for SCRATCH. Although she was able to consistently produce three elements she requires further consolidation to ensure that these are accurately realised. Thus, she has made progress with all the three element clusters but the scoring does not fully reflect this.

(d) Will singleton [s] production improve as a result of the [s] cluster intervention?

There is some evidence that work on more complex linguistic structures will generalise to more simple component parts (e.g. Gierut and Dinnsen, 1987; Gierut et al., 1987). Changes in three element [s] clusters, as noted in section (c) above, in response to work on two element [s] clusters indicated the opposite: work on two element items generalised to more complex 3 element items. The stimuli items used to measure this effect were however, limited. To investigate the opposite point of view, a set of words with [s] in all word positions was selected. These were matched in terms of age of acquisition and frequency with the treatment stimuli words. Results of the pre-intervention and post-intervention assessment for these untreated items are presented in Table 7.16 with further discussion following.

Table 7.16
Rachel's production of untreated control words pre- and post-intervention: singleton [s] in single words. Shaded items had the [s] clusters accurately realised

	T1 Pre-Intervention+	T2 Post-Intervention+	T3 Post-Intervention+
[s] word-initially	**7/11 (63.6%)**	**11 (100%)**	**11 (100%)**
SOCK	[stɒk]	[sɒk]	[sɒk]
SADDLE	[sædl]	[sædɪl]	[sædl]
SALAD	[tsælɪd]	[sælɪd]	[sælɪd]
SEAL	[sil]	[sijɪl]	[sijɪl]
SALT	[sɒlt]	[sælt]	[sɒlt]
SARDINE	[sɑdɪn]	[sɑdin]	[sɑdin]
SAW	[sɔd]	[sɔ]	[sɔ]
SECOND	[tsɛkɪnd]	[sɛkɪnd]	[sɛkɪnd]
SINGER	[sɪŋgə]	[sɪŋgə]	[sɪŋgə]
SOAP	[səʊp]	[səʊp]	[səʊp]
SAUSAGE	[dɒsɪdʒ]	[sɒsɪdʒ]	[sɒsɪdʒ]
[s] within-word	**11/14 (78.5%)**	**14/14 (100%)**	**11/14 (78.5%)**
PERSON	[pɜsɪn]	[pɜsɪn]	[pɜsɪn]
ASSEMBLY	[əsɛmblɪ]	[əsɛmblɪ]	[əsɛmblɪ]
BASKET	[bækɪt]	[bɑskɪt]	[bɑskɪt]
BISCUIT	[bɪkɪt]	[bɪskət]	[bɪskət]
PLASTER	[plæstə]	[plæstə]	[plæstə]
MONSTER	[mɒnstə]	[mɒnstə]	[mɒnstə]
ANSWER	[ænsə]	[ænsə]	[ænstə]
FATSO	[fætsəʊ]	[fætsəʊ]	[fætstəʊ]
ASTHMA	[æsmə]	[æsmə]	[æsmə]
BASIN	[beɪsɪn]	[beɪsɪn]	[beɪstɪn]
WHISPER	[wɪspə]	[wɪspə]	[wɪspə]
CASPER	[kæ'pə]	[kæspə]	[kæspə]
MUSCLE	[mʊsɪl]	[mʊsɪl]	[mʊsɪl]
SAUSAGE	[dɒsɪdʒ]	[sɒsɪdʒ]	[sɒsɪdʒ]
[s] word-finally	**8 (80%)**	**10 (100%)**	**10 (100%)**
CASE	[keɪsθ]	[keɪs]	[keɪs]
MOUSE	[maʊs]	[maʊs]	[maʊs]
CROSS	[krɒs]	[klɒs]	[klɒs]
ADDRESS	[ædrɛs]	[ədrɛs]	[ədrɛs]
CLASS	[klæt]	[klæs]	[klæs]
GRASS	[græs]	[glæs]	[glæs]
OCTOPUS	[ɒktəpɪs]	[ɒktəpɪs]	[ɒktəpɪs]
TENNIS	[tenɪs]	[tenɪs]	[tenɪs]
PALACE	[pælɪs]	[pælɪs]	[pælɪs]
CIRCUS	[sɜkɪs]	[sɜkɪs]	[sɜkɪs]

+ Words were scored correct where [s] was perceived as accurately produced.

Rachel's singleton [s] production improved from the time of the initial standardised assessment to the initial baseline assessment for the micro evaluation. Her pre-intervention performance was good and she produced an accurate [s] in about 75% of the single words sampled. Word initial [s] production was slightly, but not significantly more challenging for her than producing [s] in word-final position or within words. At T2 assessment this figure had increased to 100% for each of the three word positions. This was supported by observations from Rachel herself and from her teachers that she could now say [s]. Thus, there is evidence that the intervention aimed at [s] clusters facilitated the consolidation of Rachel's singleton [s]. Working on [s] alone may not, according to some authors have brought about the changes in the cluster production however (e.g. Gierut, 1999). There is also the possibility that Rachel may have acquired [s] on her own without the intervention since there was evidence of improvement prior to the start of the intervention from macro to micro assessments. These assessments focused on Rachel's production of [s], other fricatives and clusters and it may also be that her attention was focused on these sounds and this acted like intervention, sufficient for her to make changes in her [s] production prior to the intervention *per se*.

At T3 assessment, Rachel had maintained most of the gains noted at T2, although for the [s] within-word items, her score had returned to the pre-intervention level of 78.5%. Examinations of these errors items reveal that the nature of the errors has changed form T1 to T3. Initially she omitted [s], e.g. producing [bækɪt] for BASKET. At T3 she made errors that involved the inappropriate insertion of an [s] cluster, e.g. [ænstə] for ANSWER, [beɪstɪn] for BASIN. She may have been trying very hard at the long-term follow-up assessment to show the therapist that she had now learnt the [s] clusters that were the focus of therapy.

(e) Will production of other fricatives improve as a result of the fricative [s] treatment?
Rachel's main difficulties were with [s] and [s] clusters. However, at the initial assessment it was noted that other fricatives were also inaccurately produced on occasion. These included [z] in all word positions, [θ] in all word positions and [f] word-finally. Her production of these fricatives was thus monitored pre and post-intervention. The results are summarised in Table 7.17.

Table 7.17
Rachel's production of untreated control words pre- and post-intervention: other fricatives in single words. Shaded items had the fricatives accurately realised.

	T1 Pre-intervention+	T2 Post-intervention+	T3 Post-intervention+
[z]			
word initially	**5/5 (100%)**	**5/5 (100%)**	**5/5 (100%)**
ZOO	[zu]	[zu]	[zu]
ZEBRA	[zɛbrə]	[zɛbrə]	[zɛbrə]
ZED	[zɛd]	[zɛd]	[zɛd]
ZERO	[zɪərəʊ]	[zɪərəʊ]	[zɪərəʊ]
ZIP	[zɪp]	[zɪp]	[zɪp]
within word	**8/10 (80%)**	**10/10 (100%)**	**9/10 (90%)**
MUSIC	[mjuzɪk]	[mjuzɪk]	[mjuzɪk]
EASEL	[izθɪl]	[izɪl]	[izɪl]
POISON	[pɒɪzɪn]	[pɒɪzɪn]	[pɒɪzɪn]
PIZZA	[pitzə]	[pitzə]	[pitsə]
RAISIN	[reɪzɪn]	[reɪzɪn]	[reɪzɪn]
DAISY	[deɪzi]	[deɪzi]	[deɪzi]
PUZZLE	[pʊzl]	[pʊzl]	[pʊzl]
BLAZER	[bleɪzə]	[bleɪzə]	[bleɪstə]
PRISON	[prɪzɪn]	[prɪzɪn]	[prɪzɪn]
COUSIN	[kʊtɪn]	[kʊzɪn]	[kʊzɪn]
word finally	**9/10 (90%)**	**10/10 (100%)**	**10/10 (100%)**
MAY'S	[meɪz]	[meɪz]	[meɪz]
MAIZE	[meɪzθ]	[meɪz]	[meɪz]
SIZE	[saɪz]	[saɪz]	[saɪz]
SIGHS	[saɪz]	[saɪz]	[saɪz]
BANANAS	[bənɑnɪz]	[bənɑnɪz]	[bənɑnɪz]
ROSE	[rəʊz]	[rəʊz]	[rəʊz]
BUZZ	[bʌz]	[bʊz]	[bʊz]
LAZE	[leɪz]	[leɪz]	[leɪz]
LAYS	[leɪz]	[leɪz]	[leɪz]
BRUISE	[bruz]	[bluz]	[bluz]
[θ]			
word initially	**2/2 (100%)**	**2/2 (100%)**	**2/2 (100%)**
THIEF	[θif]	[θif]	[θif]
THIN	[θɪn]	[θɪn]	[θɪn]
within word	**1/2 (50%)**	**0/2 (0%)**	**2/2 (100%)**
TOOTHBRUSH	[tuθbrʊʃ]	[tufblʊʃ]	[tuθbrʊʃ]
TOOTHPASTE	[tupeɪs]	[tufpeɪs]	[tuθpeɪs]
word final	**2/2 (100%)**	**0/2 (0%)**	**2/2 (100%)**
MOTH	[mɒθ]	[mɒf]	[mɒθ]
TEETH	[tiθ]	[tif]	[tiθ]
[f]	**6/6 (100%)**	**6/6 (100%)**	**6/6 (100%)**
Word finally			
LEAF	[lif]	[lif]	[lif]
THIEF	[θif]	[θif]	[θif]
ROOF	[ruf]	[ruf]	[ruf]
GIRAFFE	[gəræf]	[gɪræf]	[gɪræf]
KNIFE	[naɪf]	[naɪf]	[naɪf]
CALF	[kɑf]	[kæf]	[kæf]

+ Words were scored correct where targeted fricatives were perceived as accurately produced.

Pre-intervention, Rachel's performance was close to ceiling for many of the items sampled. Her difficulties were not consistent and the number of assessment items small, making it difficult to answer the original question posed. Her [z] production in word initial position remained stable at T1, T2 and T2 at 100%. Within-word she initially scored 8/10 and this then improved to 10/10 at T2, before decreasing again to 9/10 at T3. The nature of her errors at T1 and T3 differed: at T1 she stopped [z] to [t], e.g. producing [kutɪn] for COUSIN, and inserting [θ] in [izθɪl] for EASEL.

The error noted at T3 was [bleɪstə] for BLAZER, again involving the insertion of a stop but this time also including a fricative element. Again, this may have been because Rachel was overly aware of the work that had been carried out on her clusters and wanted to demonstrate these to the therapist.

Rachel's [θ] production in the word-initial position remained at 100% at each assessment, despite some observations of difficulties with this sound in conversation. Within-word position was more challenging for her with [θ] omitted in [tu'peɪs] for TOOTHPASTE. This might however be considered normal assimilation. At T2 Rachel seemed to favour [f] instead of [θ] for all within word and word final occurrences. Although this may seem to have been a regression from her pre-intervention sampling, this is a dialectal feature that many of the children in the school use. Furthermore, word final [f] was one of the fricatives initially noted as challenging for Rachel. Thus the substitution suggested progress in that she was now able to choose from a wider repertoire of fricatives. At T3 assessment she was able to use [θ] appropriately in all word positions.

6.1.3 Spelling

Rachel's spelling and reading skills were age appropriate at the initial assessment. Work on spelling was not a specific aim of the intervention programme, but many of the intervention activities involved reading and writing so that her strengths were incorporated in the intervention. Written forms were used in each of the three interventions for each of the three wordlists. The assessment revealed that Rachel had difficulties with the spoken production of particular cluster sequences, and it was asked whether these difficulties were reflected in her spelling. Changes in Rachel's spelling of treated words are presented in Table 7.18 below.

Table 7.18
Comparison of Rachel's spelling pre- and post-intervention for treated items. Shaded items had the clusters accurately written.

	T1 Pre-intervention % clusters correct+ and examples	T2 Post-intervention % clusters correct+ and examples	T3 Post-intervention % clusters correct+ and examples
Treated: List A	**10%**	**100%**	**80%**
CLASP	<claps>	<clasp>	<clasp>
GASP	<gasp>	<gasp>	<garst>
LISP	<list>	<lisp>	<lisp>
CRISP	<cris>	<crisp>	<crisp>
CUSP	<gus>	<casp>	<casp>
GRASP	<grass>	<grasp>	<grasp>
RASP	<ras>	<rasp>	<rasp>
WASP	<wast>	<wasp>	<wastp>
WISP	<wist>	<wisp>	<wisp>
UNCLASP	<unglus>	<unclasp>	<unclasp>
Treated: List B	**80%**	**70%**	**80%**
HASTE	<hast>	<hasted>	<hast>
WEST	<west>	<west>	<west>
GUST	<gas>	<gust>	<gust>
BOAST	<bost>	<bastd>	<bost>
JEST	<jeses>	<jest>	<jest>
VEST	<sest>	<vests>	<vests>
FEAST	<fest>	<feast>	<fests>
ROOST	<rust>	<aas>	<roost>
CRUST	<riust>	<crust>	<crust>
RUST	<rust>	<ust>	<rust>
Treated:List C	**10%**	**100%**	**90%**
RISK	<rick>	<risk>	<risk>
DESK	<decs>	<besk>	<besk>
DISK	<bice>	<disc>	<bisc>
BRISK	<brisk>	<brisk>	<brisk>
CASK	<case>	<casc>	<carst>
TASK	<tak>	<task>	<task>
FLASK	<flas>	<flask>	<flask>
DUSK	<dus>	<dusk>	<bask>
KIOSK	<ceeof>	<keyosk>	<keyosk>
TUSK	<tuks>	<tusk>	<task>

+ Words were scored correct where targeted clusters were accurately spelt and not transposed or omitted

Rachel's spelling of the treated words improved significantly from T1 to T2 (t (29) =-6.595, p<.005), and T1 to T3 (t (29) =-4.785, p<.005), with no significant changes occurring between T2 and T3. This suggests that the intervention was effective in bringing about improvements in the accuracy of her written representations. Although the intervention was not specifically aimed at improving Rachel's spelling, much of the therapy involved written forms. Rachel's exposure to this resulted in improved representations of the treated words. For individual clusters it was found that [sp] and [sk] improved significantly from T1 to T2 (t(9)=-6.0, p<.001) and from T1 to T3 (t(9)=-4.583, p=.001). No significant changes were noted across intervention for the [st] items in terms of spelling, but these were approaching ceiling at the T1 assessment. As for speech, there is no evidence in the literature of [st] developing prior to [sk] and [sp], although it does occur more frequently in word-final position than the other two clusters which may be a factor in its early emergence.

To some extent, Rachel's speech difficulties were reflected in her spelling at T1. Her particular difficulty in sequencing [s] clusters is revealed in many of her spellings, e.g. <claps> for CLASP; <decs> for DESK. In addition to these transpositions, she also frequently omitted elements of the clusters, e.g. <tak> for TASK. Table 7.19 outlines the changes occurring for Rachel's spelling of the untreated control items.

Table 7.19
Comparison of Rachel's written forms pre- and post-intervention for untreated control words

Control stimuli	T1 Pre-intervention % clusters correct and examples	T2 Post-intervention % clusters correct and examples	T3 Post-intervention % clusters correct and examples
Word initial [sp]	**80%**	**95%**	**95%**
E.g. SPONGE	<spunch>	<sunch>	<spunj>
Word initial [st]	**80%**	**90%**	**75%**
E.g. STOOL	<strol>	<sull>	<stoerl>
STEP	<step>	<sept>	<step>
Word initial [sk]	**65%**	**80%**	**85%**
E.g. SKATE	<stace>	<scate>	<skate>
SKITTLE	<stickles>	<skittill>	<skilte>
SKUNK	<stunk>	<stunck>	<skaws>
SKIRT	<scert>	<serkt>	<skirt>
SKIP	<skip>	<sip>	<skip>
Other word-initial [s] clusters	**90%**	**90%**	**90%**
E.g. SQUIRREL	<scrile>	<sqwr>	<scroow>
STRAWBERRY	<starberry>	<stobrary>	<stardey>
Singleton [s]			
• **Word initial**	**90%**	**100%**	**100%**
E.g. SOCK	<stock>	<sock>	<sock>
SALT	<stolt>	<salt>	<salt>
• **Within word**	**70%**	**90%**	**90%**
E.g. ASSEMBLY	<astembley>	<sindley>	<sassemdley>
BISCUIT	<bicile>	<bisceter>	<biscit>
ANSWER	<anster>	<anster>	<anster>
BASIN	<basten>	<basern>	<busin>
WHISPER	<wister>	<wisper>	<wiseper>
CASPER	<caster>	<casper>	<casper>
MUSCLE	<mustle>	<masim>	<masil>
MONSTER	<monster>	<monter>	<moster>
• **Word final**	**90%**	**100%**	**100%**
E.g. CASE	<cast>	<case>	<case>
Other fricatives			
[z]: word initial	**100%**	**75%**	**100%**
[θ]: all positions	**100%**	**66%**	**100%**
[f]: word final	**100%**	**83.3%**	**100%**

+ Spelling scores are for the phoneme target only and do not consider the remainder of the word.

No significant changes were noted for the untreated spelling items across the three measurement intervals. However, Rachel's spelling of the untreated items at T1 was significantly better than her spelling of the treatment words (t(52)=-3.624, p=.001) which meant that there was less scope for making significant gains with this set.

6.1.4 Auditory discrimination

In Rachel's speech processing profile (Figure 7.1), the difficulties she experienced with discrimination of non-words was striking. She found it particularly hard to distinguish between sequences of consonant clusters in non-words. The intervention focused on a combination of motor programming and auditory discrimination, with three different treatments carried out: (a) speech intervention, (b) auditory discrimination intervention, and (c) speech and auditory discrimination intervention. Auditory discrimination was assessed at each of the evaluation points (T1, T2 and T3) by asking Rachel to make same / different judgements about non-word minimal pairs such as [hʊsp] / [hʊps]? The results from these assessments are shown in Table 7.20.

Table 7.20
Rachel's auditory discrimination of closely related non-words

	T1 Pre-intervention % judgements correct	T2 Post-intervention % judgements correct	T2 Post-intervention % judgements correct
List A: [sp] Treatment: speech e.g.[hʊsp] [hʊps]	20	80	100
List B: [st] Treatment: auditory discrimination e.g. [dɪst] [dɪts]	40	70	90
List C: [sk] Treatment: speech and auditory discrimination e.g.[fɪsk] [fɪks]	70	50	70

Results for auditory discrimination revealed significant improvements overall for the three cluster groups when comparing T1 and T3 scores (t(29)=-4.709, p<.001). Auditory discrimination improved slowly with no significant increase noted from T1 to T2, but significant gains made from T2 to T3 (t(29) =-2.971, p<.05). In terms of the individual clusters, there was no significant change noted for Rachel's auditory discrimination of [sk] across the intervention. [sk] words received the combined speech and auditory discrimination intervention. Discrimination of [sp] improved significantly from T1 to T2 (t(9)=-3.674, p=.005) and from T1 to T3 (t(9)=-6, p<.001). [sp] words received the speech treatment only, without discrimination being specifically addressed. The fact that no direct work on discrimination was carried out did not seem to affect Rachel's progress with the online auditory discrimination task indicating that the speech intervention may have been successful in targeting her speech processing system as a whole. Discrimination of [st] improved overall when comparing T1 and T3 scores (t(9)=-3, p<.05). [st] words received the auditory discrimination treatment and therefore this is not surprising. At the same time, her speech production of [st] was not directly worked on, but also improved. Again, this suggests that the speech processing system as a whole was affected. The nature of the treatment did not seem to matter since the input work resulted in progress with output. A problem with the research design may have meant that all three treatments were working on the speech processing system together and thus it is not realistic to separate out the specific effects of each intervention type. Furthermore, it should be noted that it is challenging to keep such treatments 'pure'. For example, the speech treatment involved listening by its very nature, and although Rachel was not encouraged to produce the items for the auditory discrimination treatment, on some occasions she did, thus rendering it not entirely 'input' work. These points are returned to in the discussion session.

Words in the [sk] list were given both speech and auditory discrimination intervention. Rachel's auditory discrimination of these words did not change significantly overall from T1 to T3, remaining at 70%. However, this starting point of 70% was higher than for the other two cluster groups. Since her auditory discrimination of [sk] was already reasonable, her cognitive resources may have been more directed toward improving her speech given the dual nature of the intervention.

6.1.5 Summary of micro evaluation

(a) Micro evaluation focussed on the specific results of Rachel's intervention by looking at changes in her production, auditory discrimination and spelling for treated stimuli as well as control items. Rachel received 10 hours of intervention which consisted of three different treatments (speech treatment, auditory discrimination treatment and combined speech and auditory discrimination work) for three different stimuli sets (words with word-final [s] clusters: [sp], [st] and [sk] respectively).

(b) There was a statistically significant main effect for time for both speech [F (2, 87) = 60.348, p< .001] and spelling [F (2, 87) = 20.107, p< .001]. Both Rachel's written and spoken production of the targeted clusters had changed over the time course of the intervention programme. The effect size for speech (eta squared = .581) was slightly greater than that for spelling (eta squared = .316), but both are large effects. Each of the interventions was successful in that it brought about improved speech production in each of the three treated stimuli lists with scores approximating 100%.

(c) A range of control stimuli was included in order to assess the broader effects of intervention. The first control set consisted of the same clusters [sp], [st] and [sk] in word initial position. For [sp] and [sk] Rachel was able to generalise from the clusters targeted in word final position in therapy to untreated items where the clusters appeared in a different word position. The results for [st] were less clear-cut. Rachel was relatively successful at the baseline phase in that she managed to produce 80% of these clusters correctly in the word initial position. A decline from 80% (at T1) to 30% (at T2) was noted, followed by a return to 80% at T3. It was suggested that the auditory discrimination treatment for this wordlist did not generalise to other word positions and had the effect of confusing Rachel's emerging production skills.

(d) Results for the non-word control items showed that Rachel was able to produce these words in a significantly improved way following intervention. This suggests that generalisation occurred as a result of the intervention, and that motor programmes and motor programming improved. There was no difference in the progress made for the three wordlists despite the different nature of the interventions.

(e) Other untreated [s] clusters were also evaluated. Improvement in Rachel's realisation of three parts [s] clusters such as [skl] and [spr] was noted, suggesting that generalisation can occur from simple to more complex structures. At the same time, her production of singleton [s], in variety of word positions, also improved. This suggested that working on the complex structures such as clusters can result in generalisation to component structures.

(f) Other fricatives problematic for Rachel were also monitored. These included [z] in all word positions, [θ] in all word positions and [f] word-finally. Her production of these fricatives improved over the course of intervention.

(g) Spelling was not the main focus of the intervention programme, but written forms were used in each of the three interventions for each of the three wordlists. Rachel's exposure to written forms resulted in improved representations of the treated words. No significant changes were noted for the untreated spelling items across the three measurement intervals. However, Rachel's spelling of the untreated items at T1 was significantly better than her spelling of the treatment words which meant that there was less scope for making significant gains with this set.

(h) Auditory discrimination was assessed at each of the evaluation points (T1, T2 and T3) by asking Rachel to make same / different judgements about non-word minimal pairs such as [hʊsp] / [hʊps]. Results for auditory discrimination revealed significant improvements overall for the three cluster groups when comparing T1 and T3 scores ($t(29)=-4.709$, $p<.001$). In terms of the individual clusters, there was no significant change noted for Rachel's auditory discrimination of [sk] across the intervention. [sk] words received the combined speech and auditory discrimination intervention. Since her auditory discrimination of [sk] was already reasonably good (70% accurate), her cognitive resources may have been more directed toward improving her speech given the dual nature of the intervention.

(i) The research design did not reveal a clear effect from the different treatments: working on input only resulted in input and output gains, while working on output only resulted in the same gains. There was some evidence that the mixed treatment (input and output) was less effective in terms of generalisation to some of the control items. Such issues are considered in greater detail in the discussion section.

6.2. Macro evaluation

Short-term follow-up took place in January 2003 when Rachel was CA 8;1, approximately 6 months after completion of her intervention programme. Long-term follow-up took place some 9 months later at CA 8;10. The complete assessment as carried out initially in Section 2, was repeated in order to assess her progress in terms of speech, language and literacy. Assessment is grouped into four main areas: (6.2.1) standardised language assessments, (6.2.2) speech profiling carried out within a psycholinguistic framework, (6.2.3) speech analysis, and (6.2.4) child interview and parent / teacher report.

6.2.1 Standardised language assessment

Standardised tests administered at the start of the intervention, were re-administered, and results are presented in Table 7.21.

Table 7.21
Comparison of Rachel's standardised speech, language and literacy assessments at CA 7;1 (pre-intervention) and CA 8;1 and 8:10 (post-intervention)

Assessment	Area tapped	PRE INTERVENTION CA 7;1 Score	Age-equivalent	POST INTERVENTION CA 8;1 Score	Age-equivalent	POST INTERVENTION CA 8;10 Score	Age equivalent
Receptive language							
Test of reception of grammar (TROG, Bishop, 1989)	Receptive grammar	Std Score: 104 Centile: 62.5	9;0	Std Score: 104 Centile: 62.5	9;0	Std Score: 104 Centile: 62.5	9;0
British Picture Vocabulary Scale (BPVS, Dunn et al., 1997)	Receptive vocabulary	Std Score: 88 Centile: 22.5	6;2	Std Score: 92 Centile: 30	7;2	Std Score: 100 Centile: 50	8;10
Receptive Subtests of CELF (Clinical Evaluation of Language Fundamentals – UK Edition, Wiig et al., (2001).	Receptive language	Std Score: 10 Centile: 50		Std Score: 10 Centile: 50		Std Score: 11 Centile: 74	
Expressive language							
Renfrew Word Finding Vocabulary Test (Renfrew, 1995)*	Expressive vocabulary	Z Score: -0.1	6;12	Z Score: 1.66	8;6	Z Score: 1.66	8;6
Clinical Evaluation of Language Fundamentals (CELF- 3), Expressive Subtests (Semel et al.,1995)	Expressive grammar	Std Score: 9 Centile: 40		Std Score: 9 Centile: 40		Std Score: 10 Centile: 50	
Edinburgh Articulation Test (EAT, Anthony et al., 1971))**	Articulation and naming	Std Score = 77	5;6	Std Score = 86	5;8	Std Score = 106	6;0
Literacy measures							
Schonell Reading Test (Newton and Thompson, 1982)	Reading single words	Reading age = 7;9 years		Reading age = 8;2 years		Reading age = 8;9 years	
Schonell Spelling Test (Newton and Thompson, 1982)	Writing single words from dictation	Spelling age=8;6		Spelling age=8;5		Spelling age=8;8 years	

* Renfrew Word Finding Vocabulary Test has norms up to age 8;6 which were used for Ben at all assessment points beyond this age
**EAT is designed for use with children up to the age of 6;0. Rachel's scores were calculated using this upper age limit although she was older than this at each assessment.

In terms of receptive language, Rachel's TROG score (Bishop, 1983) did not change over the three assessments. However, the score is appropriate given her chronological age, and no cause for concern. Her performance on the other two receptive language measures showed steady increases over the course of the project. Her BPVS score (Dunn et al., 1997) for receptive vocabulary was slightly delayed at T1. At T2 the gap between Rachel and her chronologically matched peers remained. However at T3 her score was found to be age-appropriate. It is suggested that this may be because her auditory discrimination had improved which had in turn improved her new word learning skills. Her scores on the receptive subtests of the CELF (Wiig et al., 2001) remained age-appropriate throughout the intervention with a slight, but not significant increase noted at T3. Similarly, her expressive language skills remained appropriate for her age with some slight but insignificant gains noted over the assessments. Her receptive and expressive language skills are age-appropriate.

Rachel's performance on the literacy tests may be slightly more cause for concern. At T1 her age equivalent scores were well in advance of her peers for both reading and spelling. At T2 these scores remained age-appropriate although they were slightly less advanced than at the initial assessment. At T3, the scores were slightly, although not significantly delayed for her age. Although each set of literacy results is not a cause for concern in its own right, the trend in relation to her age-matched peers is slightly worrying especially given the history of her speech difficulties. It will be important that Rachel's literacy development is carefully monitored so that the gap between her and her age-matched peers does not become a significant one. When comparing reading and spelling, it is interesting to note that at the first two assessments her reading performance was weaker than her spelling performance, an unusual trend (Bishop and Clarkson, 2003). At T3 assessment this pattern had changed and the two skills were now almost equally matched. Again, it will be important to ensure that her spelling, a potentially challenging area for children with a history of speech difficulties, does not fall behind.

6.2.2 Speech profiling in a psycholinguistic framework

Tests used to build Rachel's initial speech processing profile (fig 7.1) were carried out again in order to determine if any changes in her profile had occurred. The updated profile is presented in Figure 7.4. Changes on both input and output parts of the profile were found: Rachel now performed age-appropriately on all aspects of the profile. Her ability to discriminate between real words (level D) and non-words (level B) was now age appropriate. The output difficulties previously experienced at levels G,I and J had also now resolved. Her self-monitoring abilities (level L) were also judged to have improved.

Figure 7.4

Rachel's speech processing profile at CA 8;1 (from Stackhouse and Wells, 1997). Changes from the earlier profile (fig 7.1 at CA 7;1) are indicated by shaded areas

√ = age appropriate performance

INPUT

F Is the child aware of the internal structure of phonological representations?
√ - Rhyming test (Vance et al. 1994)
√- PhAB picture alliteration subtest (Frederikson et al. 1997)

E Are the child's phonological representations accurate?
√ - Auditory lexical decision task (Constable et al., 1997)
√ - Sorting tasks

D Can the child discriminate between real words?
√ – Real word discrimination test (Bridgeman and Snowling 1988)
√ - Aston index discrimination subtest (Newton and Thompson 1982)
√- PhAB alliteration subtest (Frederikson et al. 1997)

C Does the child have language specific representations of word structures?

Not tested

B Can the child discriminate speech sounds without reference to lexical representations?
√ – Non-word discrimination test (Bridgeman and Snowling 1988)

A Does the child have adequate auditory perception?
√ - audiometry

OUTPUT

G Can the child access accurate motor programmes?
√ – Single word naming test (Constable et al., 1997)
√ – Word-finding vocabulary test (Renfrew 1995)

H Can the child manipulate phonological units?
√ - PhAB Spoonerism subtest subtest (Frederikson et al. 1997)
√ - PAT rhyme fluency subtest subtest (Muter et al. 1997)

I Can the child articulate real words accurately?
√ – Real word repetition subtest (Constable et al., 1997)
√ - Aston index blending subtest – real Words (Newton and Thompson 1982)
√ - Real word test (Snowling)

J Can the child articulate speech without reference to lexical representations?
√ – Aston index blending subtest – nonwords (Newton and Thompson 1982)
√ – Non-word repetition subtest (Constable et al., 1997)
√ - Non-words test (Snowling)

K Does the child have adequate sound production skills?
√ - Stimulable for all sounds
√ - Oro-motor assessment (Nuffield Dyspraxia Programme, Connery et al. 1994)

L Does the child reject her own erroneous forms?
Yes

6.2.3 Speech analysis

A post-intervention PACS (Grunwell, 1985) was carried out to provide information on Rachel's speech production system (Table 7.22). This was compared with the summary of the findings from the initial assessment (section 2.3.1). Rachel's severity indices remained high and unchanged.

Cluster reduction was significantly reduced in Rachel's naming of PACs and other pictures. Initially noted for 72% of possible instances, it was noted for only 5% of possible instances at the post-intervention follow-ups. These instances were all noted for [s] clusters in word-initial position (e.g. [sæmps] for STAMPS) but Rachel was able to correct herself once she had produced the word. Rachel still found it hard to produce some multisyllabic words. Sequencing errors (e.g. [tætikɪlə] for CATERPILLAR) and other sound confusions (e.g. [hɒsbɪkɪl] for HOSPITAL) were still noted in a few instances of Rachel's spontaneous speech. However, her ability to repeat these accurately had improved from the initial assessment. When Rachel produced these multisyllabic words erroneously, she was able to self-correct. Stopping of [s] was no longer noted in Rachel's speech.

6.2.4 Child interview and parent / teacher report

The child interview, and evaluation from teachers and parents was carried out again at CA 8;10 to provide further impressions of changes in Rachel's speech.

6.2.4.1 Child interview

The same interview procedure as described in section 2.4.1 and Table 7.3 was carried out at the long-term follow-up assessment. The results of the second interview are summarised in Table 7.23 together with the results from the initial interview for comparison. Rachel showed good insights into her speech and the progress that she had made in therapy. Her attitudes to both speech and literacy were positive. She is confident about her spoken language abilities now, but realises that literacy can pose challenges and is something that one can practise in order to achieve success.

Table 7.22
Comparison of Rachel's speech data at CA 7;2 (pre-intervention) with CA 8;2 (post-intervention)

Assessment	Pre-intervention CA 7;2	Post-intervention CA 8;2
Severity indices	PCC 96.1% PVC 100% PPC 97.5%	PCC 94.8% PVC 100% PPC 96.7 %
Phonetic inventory	Word initial: all phonemes Word medial: all phonemes Word final: all phonemes	Word initial: all phonemes Word medial: all phonemes Word final: all phonemes
Stimulability	All phonemes	All phonemes
Phonological processes analysis (% use)	Developmental processes: stopping (78%), reduction of [s] clusters (72%)	Developmental processes: reduction of [s] clusters (5%)
Single word speech sample	[tætikɪlə] for CATERPILLAR [hɒsbɪkɪl] for HOSPITAL [pun] for SPOON [kul] for SCHOOL [dɛks] for DESK [dɪdəd] for SCISSORS [æs] for ASK [æt] for ASK [wɪʔ] for WITH [lit] for LEAF [bɔɪd] for BOYS	[kætɪpɪlə] for CATERPILLAR [hɒsbɪkɪl] for HOSPITAL [spun] for SPOON [skul] for SCHOOL [dɛsk] for DESK [sɪzəs] for SCISSORS [æst] for ASK [æsk] for ASK [wɪθ] for WITH [lif] for LEAF [bɔɪz] for BOYS
Connected speech sample	[θəmænwəʊntbɑɪ.ɪt] for THE MAN WON'T BUY IT [ðɪsmænɪzwɪmɪn] for THIS MAN IS SWIMMING [ɪtwɜgɛərɪ] for IT WERE SCARY [ætkwɪtmɪt] for AT CHRISTMAS	[fɑɪvpækɪtsəkrɪsps] for FIVE PACKETS OF CRISPS [ænwɪswamɪnθəsi] for AND WE SWAM IN THE SEA [aʊglæsgɒtəprɑɪz] for OUR CLASS GOT A PRIZE [ɑɪdɒnlɑɪkɪt] for I DON'T LIKE IT

Table 7.23
Summary of findings from Rachel's semi-structured interview at CA 7;8 (during intervention) and CA 8;10 (post-intervention at long-term follow-up)

Area of questioning	Main findings at CA 7;8	Main findings at CA 8:10
Rachel's experience of SLT • Present	Enjoys therapy a great deal Doesn't enjoy spelling especially doing the lengthy baselines	Enjoyed therapy a great deal and want to have more even though her speech difficulties have resolved The writing was a challenge for her
• Past	Remembers previous therapy and therapists well	
Rachel's perception and awareness of own speech	She needed to come to speech mainly because of not being able to say 's' She likes talking both in the classroom and to her friends	She had some problems with talking but she can do everything now. She loves chatting to her friends and family.
Rachel's perceptions of communication more generally	Most people in England talk the same language but people in other countries talk different languages. She was aware of a child in the school who does not have English as a first language	
Rachel's attitudes to literacy	Reading is easy and fun for her. Writing is more challenging Reading and writing are both important for success	Reading books at home is fun. Sometimes reading and writing can be hard at school. She wants to get a prize for spelling and knows she will have to practise spelling everyday to achieve this.

6.2.4.2 Teacher report

Rachel's class teacher and LSA were asked questions about changes in her speech post-intervention. Both agreed that she had made good progress and that there was now nothing they could think of that was wrong with her speech. They both thought that speech and language therapy was no longer necessary, and expressed positive feelings about her speech, language, literacy and social skills.

In order to provide further information about Rachel's academic progress over the course of the intervention, SATs results were obtained from the assessments carried out at the end of Year 2 (prior to starting intervention, CA 7;3) and at the end of Year 3 (following intervention, CA 8;5). These results are shown in Table 7.24.

Table 7.24
Rachel's SATs results from pre-intervention (Year 2) to post-intervention (Year 3)

Area	Year 2: CA 7;3	Year 3: CA 8;5	Comment*
Reading	2B	2C	Decreased by 1 grade
Writing (includes spelling and handwriting)	2B	2B	Remained the same
Numeracy	2A	3C	Improved 1 grade

* the numbers indicate the child's level of ability which moves from 1 upwards through to a target of 4 by the end of key stage 2. An A symbol indicates the child is almost ready to progress to the following level, whereas C or B suggests that they need further consolidation at that level. Here changes are reported in 'grades' which are derived from the number of 'letter' changes occurring, i.e. 1B to 1A constitutes an improvement of 1 grade. One would expect an average child to move 2-3 grades in the course of a year.

Rachel's assessment scores for reading show a decrease in her abilities when compared to the expected standards for her year group. Her teacher reported that at the Year 3 assessment Rachel had performed poorly and the result was not a true indication of her skills. She reported that Rachel had started to cry halfway through the reading passage and had not coped well with the assessment situation. Her writing and spelling assessments revealed a stable performance which teachers were not concerned about given the results of other children in the class. Nevertheless, one might expect to see some gains being made over the course of the year. These literacy results are a cause for concern given the results from the standardised tests in Table 7.21 which also showed Rachel to be performing slightly less well in relation to her peers than at the start of the project. At these assessments she did not seem anxious.

Rachel's numeracy scores had improved in line with what one might expect given the amount of time that had elapsed.

6.2.4.3 Parent report

Rachel's parents were very pleased with the progress that Rachel had made over the course of intervention. They considered Rachel to have no residual speech difficulties post-intervention and were happy with all aspects of her communication. They felt that it was appropriate for intervention to stop.

6.2.5 Summary of macro evaluation

1. Rachel's expressive and receptive language skills as measured by standardised tests outlined in 7.21, remained appropriate for her age.

2. Rachel's literacy performance is now some cause for concern. Her reading and spelling age as measured on single word tests (Schonell spelling and reading tests, Newton and Thompson, 1982) remained appropriate for her age, but showed a trend of decreasing skills in relation to her peers. These findings were supported by the SATs results obtained from Rachel's teacher which showed no change in her spelling over the course of a year, and a decline in the standard expected for her reading. Given the links between speech and literacy, and her history of speech difficulties, her literacy progress should be carefully monitored.

3. Rachel's speech processing profile (Figure 7.3) showed a range of changes in both input and output: she was found to be performing age-appropriately in relation to her peers for all input and output tasks.

4. Rachel's self-monitoring skills were judged to have improved over the course of the intervention, and this enabled her to make self-corrections for some of the errors still noted in her speech. These errors include persisting difficulties with multisyllabic words and occasional cluster reduction of [s] clusters. Her immature phonological processes of cluster reduction and stopping had significantly decreased (from 72%) with 5% of possible clusters now reduced, and no instances of stopping noted.

5. Rachel herself, her parents and teachers were pleased with her speech progress and no longer felt that intervention was needed.

7. DISCUSSION

Normally-developing children do not have difficulty in the perception or production of word-final consonant clusters. Rachel, the child discussed in this chapter, clearly had specific difficulties with her speech production and perception of word-final clusters. Research into children's speech and spelling development has suggested that consonant clusters can pose particular difficulties for many children. Most of the research to date has focused on spelling of word-final consonant clusters (e.g. Treiman, 1985) or speech production of word-initial clusters (e.g. Powell and Elbert, 1984; Smit, 1993; Gierut, 1999; Gierut and O'Connor, 2002). It is known that [s] + stop clusters are different to other clusters, and require specific intervention to promote their accurate production (Barlow, 2001), and that treatment of [s] + stop clusters does not promote widespread change across all consonant sequences, while treatment of other consonant sequences can (Gierut, 1999).

Rachel's intervention of word final [s]+ stop clusters resulted in generalisation to other more complex, three-element clusters as well as to singleton [s] and other fricatives.
Mcleod et al. (1997) have reported that there is no clear developmental hierarchy for the development of [s] clusters word initially or finally, although it is known that [s] production may be easier for children acquiring this phoneme in word final position (Grunwell, 1985; Redford et al., 1997). Again, extensive generalisation was found across word position with Rachel able to apply her knowledge of the word-final consonants clusters to the same clusters in other positions. In terms of the specific [s]+stop clusters, there is some evidence that [sk] may be slightly later acquired on average, when compared to [sp] and [st]. This finding did not apply to Rachel. However, it was observed that [st] was more advanced in both her speech and spelling than the other two clusters. Although this is not reported in any of the cluster studies, [st] does occur more frequently in word-final position than the other two clusters which may be a factor in its early emergence.

Target selection was an important part of the intervention planning for Rachel. While intervention focused on three [s] + stop cluster in the word-final position, a range of untreated controls were used to determine the generalisation effects beyond the treatment stimuli. Gierut et al. (1987) suggest that the process of target selection should involve classification of a child's knowledge of phonemes into categories ranging from 'no phonological knowledge' (i.e. the child does not have the phoneme in their repertoire) to 'maximal phonological knowledge' where they are consistently able to use the sound in appropriate ways in all word positions. It is suggested that choosing targets about which the child has no knowledge will result in more widespread change than choosing those about which some knowledge exists. Considering the difference in baselines at the start of the study, it seems likely that Rachel's PPK of [st] was higher than for the other two groups. The generalisation pattern observed in this study supports the theory: Rachel improved not only in her ability to produce the [s] clusters but also in her ability to produce singleton [s] and other fricatives, most notably [z]. However, it should be cautioned that Rachel was becoming increasingly proficient in her singleton [s] production during the initial assessment, and thus she may have been ready to acquire that phoneme in any event. It is also interesting to note that contrary to the predictions of Gierut et al. (1987), Rachel's speech production of thee-part consonant clusters also improved. Detractors of Gierut et al.'s (1987) complexity accounts of treatment efficacy (e.g. Williams, 1991) suggest that the categories of phonological knowledge may be too broad to characterise the precise level of knowledge, and further that in real-life settings complex targets are often not suitable treatment goals since children find them too challenging in the initial stages of therapy. From Rachel's intervention one might conclude that choosing moderately challenging targets is a successful compromise with the child not being outfaced and generalisation occurring both downwards to the less complex structures and upwards to the more complex aspects.

Rachel's intervention programme made use of new lexical items. It was hypothesised that it would be easier for her to acquire the new motor programmes from afresh, rather than revise already existing ones. This is by no means a novel therapy approach (e.g. see Bryan and Howard, 1992). In Rachel's case, no significant difference was noted in the way in which old and new items improved. However, it may be that there were sufficient novel items to stimulate the online motor-programming device and sufficient impetus to shake-up the motor-programme store.

Rachel received three different interventions, which were applied to three different wordlists. Significant differences were not noted in response to these differing interventions: all of the interventions were effective in targeting the treatment stimuli. Widespread generalisation was noted to each of the control sets of words, although the wordlist with [s] cluster word-initially revealed some interesting results. Here it was found that the accuracy of [st] production decreased following the auditory discrimination intervention. As noted, [st] seemed different to the other two clusters [sp] and [sk]: Rachel obtained pre-intervention scores for speech and spelling that were significantly higher for this phoneme than the other two. It has been suggested that the auditory discrimination treatment for this wordlist did not generalise to other word positions and had the effect of confusing Rachel's emerging production skills. However, it is difficult to know if the decline observed was due to characteristics specific to the [st] cluster and the stage that Rachel was at in acquiring the cluster, or due to the input intervention. It is most likely that the results reflect an interaction of these two factors.

There are other effects of intervention that are hard to disentangle. The aim of applying three different treatments to three cluster sets was to monitor the progress observed for each set, almost as if three different children were receiving three different treatments. This logic presupposes that the three [s] clusters are distinct entities. Clearly this may not be the case. Results of the study and patterns of generalisation observed suggest that each treatment affected the speech processing system as a whole and effects could not be separated from word-list to word-list. This is a useful finding in that therapists can consider [s] clusters, such as the ones targeted in this study, as being very closely linked with great overlap in the way they are stored in children's speech processing system. However, despite this fact, it is important to consider baseline PPK as children may respond differently to intervention depending on the knowledge they already have about particular clusters.

At the start of the project, Rachel was considered to be a resilient child: one whose persisting speech difficulties had not affected her literacy and academic and social success. The concept of resilience is an interesting one that has been little researched in relation to speech and language. Some authors (e.g. Werner and Smith, 1982) have attempted to profile resilient children, looking at factors which seem to predispose 'at-risk children' to cope with their particular environment and difficulties in a positive way. Although the focus of this research is not specifically on speech and language, findings have suggested that autonomous children with good social skills are ones who are likely to cope best with difficulties faced. Certainly, Rachel presented as an independent girl with excellent social and pragmatic language skills.

However, the positive picture of Rachel's literacy skills presented at the start of the chapter, was brought into question towards the end of the study: Rachel's literacy progress was not as great as one might have expected in relation to her peers and given the amount of time that had elapsed. Bishop and Adam's (1990) critical age hypothesis predicts that children such as Rachel with speech difficulties persisting beyond age 5;5 face an increased risk of experiencing literacy difficulties. Rachel may have been enjoying a temporary respite from literacy difficulties that will surface in the future. Following the intervention given in this study, she was discharged from speech and language therapy by the local SLT service as her difficulties were now considered resolved. This raises the question of criteria for discharge: Joffe, Penn and Doyle (1996) investigated the persisting difficulties faced by children who had been discharged from therapy and were considered 'remediated.' In many cases they found such decisions were premature, and called for a broad-based perspective for therapy discharge criteria. One way of developing such a perspective is through longitudinal studies. The longitudinal study carried out by Nathan, Stackhouse, Goulandris and Snowling (2004) found that children whose speech difficulties persisted beyond 5;5 typically had speech processing profiles that were resistant to change. These children seemed to have core deficits that characterised their condition. The fact that Rachel's speech processing profile changed after the intervention and indeed 'normalised' at each level, suggests that she might not have these core difficulties. However, the fact that she does still evidence some difficulties in her production of multi-syllabic words may mean that underlying difficulties still remain and that the speech task were not hard enough to tap into these residual problems. Question that remain unanswered about Rachel are (a) whether earlier and intensive intervention would have resolved her speech difficulties and normalised her profile, and (b) whether or not she will go on to experience literacy difficulties.

CHAPTER 8: BEN

Page

Chapter outline

Older children with persisting speech problems face a number of risks. They are at increased risk of experiencing psychosocial difficulties: low self-esteem, poor self-image and possibly bullying and stigmatisation (Nash, Stengelhofen, Toombs, Brown and Kellow, 2001). These children are also at particular risk of being poor spellers due to the shared phonological underpinnings for speech and spelling (Lewis, Freebairn and Taylor, 2002). A study by Clark-Klein and Hodson (1995) revealed that children with histories of speech difficulties made more phonologically deviant misspellings than their normally developing peers. Speech sound errors do not necessarily map directly onto spelling errors (McCormick, 1995), but rather difficulty with speech may result in imprecise phonological representations of words in the lexicon (Treiman, 1985; Stackhouse, 1996), resulting in inconsistent erroneous spellings. Children with speech sound disorders at pre-school may be at risk for later spelling difficulties due to poor phonological awareness and difficulties in phonological coding in verbal memory. Bishop and Adams (1990) contrasted literacy outcomes for two groups of 8-year-old children: a group whose speech difficulties had resolved, and a group whose speech difficulties remained. They found that a significant number of the children with persisting speech problems had literacy difficulties, while their resolved counterparts did not. Their critical age hypothesis thus suggests that children whose speech difficulties have not resolved by 5;6 face an increased risk of experiencing difficulties with literacy as they get older.

It is important to consider the nature of speech difficulties in studies looking at the relationship between speech and spelling and long-term outcomes. Studies of children with organic speech difficulties (e.g. dysarthria, or level K on Stackhouse and Wells' (1997) speech processing profile) found that such speech difficulties are not linked to spelling problems (e.g. Stackhouse, 1982; Bishop and Robson, 1989). Similarly, results from more recent research show that children with *articulation* difficulties are not at an increased risk of having literacy problems provided that they have good language skills and the articulation difficulties are not severe (Bishop and Clarkson, 2003). Dodd, Gillon, Oerlemans, Russell, Syrmis and Wilson (1995) found that children with disordered phonology are at greatest risk for spelling difficulties, but that children with delayed phonology and articulation difficulties are also at some risk. Speech difficulties are thought to assume importance in terms of literacy outcomes when they co-occur with language difficulties. Bishop and Clarkson (2003) reported that the group of children with both speech *and* language disorders were the poorest performers in their study, and the results from a longitudinal study by Nathan, Stackhouse, Goulandris and Snowling (in press) confirmed this finding.

Bishop and Clarkson (2003) observe that spelling skills are frequently overlooked when evaluating children with speech and language difficulties. These authors note that literacy research has tended to focus more on reading than spelling, and that it is often argued that spelling performance can be deduced from reading performance since the two are typically highly correlated. They argue that spelling offers an important window into the developing speech and language system since it is a late-acquired and complex skill. This chapter focuses on the oldest participant in the study, a boy called Ben with persisting speech problems and associated literacy difficulties. The chapter centres on some of the difficulties faced by older children with unresolved speech problems. It explores links between speech and spelling in this population; the nature of persistent speech problems and the reasons they may be resistant to change. The chapter describes Ben's (1) background, (2) assessment, (3) macro intervention planning, (4) micro intervention planning and (5) implementation of his intervention programme. It concludes with (6) an evaluation of the intervention, and (7) discussion of the themes specific to this case.

1. BACKGROUND INFORMATION

Ben was 8;6 at the start of the study and in Year 4 in a mainstream school. His involvement in the study continued until he was 10;3 and in Year 6.

1.1. Developmental

Ben's birth and early developmental history was normal in all aspects with the exception of the slightly delayed onset of first words. His father reported that he spoke his first words a little later than his older sister, but that he was very communicative. Ben had a series of middle ear infections as a baby, but these resolved before he was 3;0. He has passed all hearing screens since starting school. Motor milestones were achieved within normal age limits and no feeding difficulties were noted. Ben is right-handed.

1.2 Educational

Ben is in the lower ability group in his class and receives some additional learning support in a small group for the slower learners in the class. This support is for literacy and numeracy. He has good attention in a 1:1 situation and can generally sustain attention in the classroom, although at times he needs to be re-focussed on the task at hand. His teacher described him as a quiet and hard-working boy. She expressed concerns about his spelling and reading, which she noticed had become increasingly weak as literacy demands grew in Year 4. She commented that some of his speech errors were noted in his spelling. Ben is a creative child whose favourite subject is art.

IQ results (WASI, Wechsler, 1999) suggested a verbal IQ of 82, a performance IQ of 115 and a full-scale score of 98 which falls in the average range. Verbal IQ is often recognised as the best predictor of future academic achievement (Townend, 2002).

1.3 Medical

Ben's medical history is uneventful. He is a healthy child, seldom absent from school and with no reported episodes of hospitalisation or serious illness.

1.4 Speech and language therapy

Ben was referred for speech and language therapy for the first time at CA 6;3. This late referral seems to have been due to the fact that his language was good, and his parents and teachers considered that he would grow out of his speech difficulties. Assessment at this time revealed receptive and expressive language appropriate for his age. His speech was described as immature for his age with a range of persisting phonological difficulties. Ben was then seen in school at varying intervals by the local SLT service. He received therapy both individually and in a small group.

At the start of this project at CA 8;6, Ben was no longer receiving therapy on a regular basis, but was being reviewed each term with advice being given to the school staff. His remaining areas of difficulty included production of [st] and [str] (typically reduced to [s]), [ʃ] and [tʃ] (also produced as [s]), and [θ] and [ð], inconsistently produced as [v]. His teacher's main concern was that he is not always easy to understand in conversation, and that his speech seems to affect his spelling skills.

1.5 Family

Ben lives with his father and one sister, two years older than him. His parents had recently divorced, and at the time of assessment Ben was upset about this and adjusting to a new routine. He spends every second weekend with his mother. Ben is very close to his sister and the siblings meet at break time to play together.

1.6 Social

Ben is a quiet, gentle boy who needs to be encouraged to express his opinions in the classroom situation. In the one-to-one situation with an adult he was initially shy but once he gained confidence was talkative and friendly. He has few close friends in his class, and seems to prefer the company of adults, or his sister. School staff have expressed concern about his social withdrawal and the fact that his sister is his closest companion. He is sometimes a target for teasing by the other children in his class: the focus of the teasing seems to be on his speech and shyness.

1.7 Summary of background information

Ben has a normal developmental history with the exception of delayed speech. Socially and emotionally, he was experiencing some difficulties which may be related to his parents' recent divorce as well as his speech difficulties. Academically Ben requires additional support to maintain his position in the class. Increasingly, his speech errors have been observed in his spelling, and there are concerns about his literacy progress in general. Ben's speech difficulties at CA 8;6 were subtle but persisting. He was referred late to speech and language therapy (CA 6;3) but in the past two years has received intervention which has had some effect on his phonology. However, difficulties remain and there is concern that Ben may be at risk for experiencing further spelling and reading difficulties linked to his persistent speech problems.

2. ASSESSMENT

Assessment was carried out at the start of the study when Ben was in Year 4 (CA 8;6 –8;9). The entire assessment procedure was re-administered on completion of the intervention, when he was in Year 5 (CA 9;7 – 9;8) and at long-term follow-up in Year 4 (CA 10;2 - 10;3). Assessment was grouped into four main areas: (1) standardised language assessment, (2) speech profiling carried out within the psycholinguistic framework, (3) phonological analysis, and (4) child interview and parent / teacher report. Results of the standardised assessments are presented in section 2.1, followed by a discussion of the speech profiling (2.2), speech analysis (2.3) and child interview and parent / teacher report (2.4). The re-assessments are discussed in the evaluation sections of the chapter.

2.1 Standardised language assessment

The standardised assessment revealed that Ben has a range of difficulties in all aspects of his language development. He performed below-age for both the expressive and receptive vocabulary tests contrary to what had been reported from other language assessments. His understanding of grammar is substantially delayed for his age. These language delays together with his speech difficulties place him at increased risk for experiencing literacy difficulties (Bishop and Clarkson, 2003). The literacy measures showed that Ben is approximately one year delayed in his reading ability. His teacher cautioned that although he decodes well, his reading comprehension is poor. The Schonell Graded Reading Test (Newton and Thompson, 1982) does not assess reading comprehension. His spelling is more delayed, by approximately 18 months, and this accords with the strong links between speech and spelling outlined in the introduction to this chapter by authors such as Lewis et al., (2002) and Clark-Klein and Hodson (1995). The results of the standardised assessments are summarised in Table 8.1

Table 8.1

Summary of Ben's standardised speech, language and literacy assessment results at CA 8;8

Assessment	Area tapped	Standard score	Centile	Age equivalent
Receptive language				
Test of reception of grammar (TROG, Bishop, 1989)	Receptive grammar	87	25	7;0
British Picture Vocabulary Scale (BPVS, Dunn et al., 1997)	Receptive vocabulary	78	7	6;2
Clinical Evaluation of Language Fundamentals (CELF- 3), Receptive Subtests (Semel et al., 1995)	Receptive language	9	40	Age appropriate
Expressive language				
Renfrew Word Finding Vocabulary Test (Renfrew, 1995)	Expressive vocabulary		25	6;11
Clinical Evaluation of Language Fundamentals (CELF- 3), Expressive Subtests (Semel et al.,1995)	Expressive language.	9	40	Age appropriate
Edinburgh Articulation test* (EAT, Anthony et al., 1971)	Articulation and naming	77		5;6
Literacy measures				
Schonell Graded Reading Test (Newton and Thompson, 1982)	Reading single words			Reading age = 7;7 years
Schonell Spelling Test (Newton and Thompson, 1982)	Writing single words from dictation			Spelling age=7;1

* Renfrew word finding vocabulary test has norms up to age 8;6 which were used for Ben at CA 8;8
**EAT is designed for use with children up to the age of 6;0. Ben's scores were calculated using this upper age limit although he was 8;8 at the time of the assessment.

2.2 Speech profiling in a psycholinguistic framework

The speech processing profile from Stackhouse and Wells (1997) was used as a framework for organising the data from this part of the assessment. At each level of the profile at least one assessment was carried out[18]. In some cases this included data already obtained from the standardised tests, and in other cases unpublished, non-standardised tests or subtests from standardised materials were used (see Appendix 2). Ben's speech processing profile at 8;8 is shown in Figure 8.1. The ticks and crosses shown on the profile indicate Ben's performance in relation to other children of his chronological age, with one tick indicating age-appropriate skills, and further ticks or crosses showing the number of standard deviations above or below the mean. The completed profile is presented in Figure 8.1.

2.2.1 Overview of psycholinguistic speech processing profile

In general, Ben's surface speech deficits were relatively minor. However, examination of his profile revealed that he had many specific difficulties with more complex tasks and his problems are subtle, but widespread throughout the profile. He had difficulties with both input and output processing.

2.2.2 Strengths

Ben's profile showed a range of strengths: He has generally good phonological representations as tested by specific sorting games focusing on his error sounds, as well as the auditory lexical decision task (Constable et al., 1997). He has good awareness of the internal structure of phonological representations and equally good skills in the manipulation of phonological units. Ben had good phoneme-grapheme links (he could write all letters to dictation), and this fits in with his generally intact input phonological skills. However his phoneme-grapheme links may be more questionable when he is faced with a string of phonemes, e.g. in a single word writing to dictation task.

Ben's ability to devise online motor programmes was relatively good. When presented with the written word <biscuits> he did not recognise the word, and was able to sound it out by grapheme-phoneme conversion, and then blend the sounds and accurately devise an 'online' motor programme. At first he rehearsed this 'new' motor programme in a whispered voice: he was heard to say the word accurately: [bɪskɪts]. However, having carried out this rehearsal, he then recognised the word as a familiar one after all, and

[18] With the exception of level C which is not routinely assessed in monolingual children (Stackhouse and Wells, 1997).

produced it at normal volume using his stored motor programme: [bɪsɪts]. Examples such as this one were key in planning the intervention programme.

Figure 8.1
Ben's speech processing profile at age 8;8 (from Stackhouse and Wells, 1997)
√ = age appropriate performance
X = 1 s.d below the expected mean for his age
XX = 2 s.d below the expected mean for his age
XXX = 3 s.d. below the expected mean for his age

INPUT

F Is the child aware of the internal structure of phonological representations?
√ - Rhyming test (Vance et al. 1994)
√- PhAB picture alliteration subtest (Frederikson et al. 1997)
√ - Sorting games

E Are the child's phonological representations accurate?
√ - Auditory lexical decision task (Constable et al., 1997)
√ - Sorting games

D Can the child discriminate between real words?
XXX – Real word discrimination test (Bridgeman and Snowling 1988)
√ - Aston index discrimination subtest (Newton and Thompson 1982)
X - PhAB alliteration subtest (Frederikson et al. 1997)

C Does the child have language specific representations of word structures?

Not tested

B Can the child discriminate speech sounds without reference to lexical representations?
XXX – Non-word discrimination test (Bridgeman and Snowling 1988)
√ - Aston index discrimination subtest (Newton and Thompson 1982)

A Does the child have adequate auditory perception?
√ - audiometry. But has history of middle ear infections as a baby.

OUTPUT

G Can the child access accurate motor programmes?
X – Single word naming test (Constable et al., 1997)
X – Word-finding vocabulary test (Renfrew 1995)
X – Edinburgh articulation test (Anthony et al. 1971)

H Can the child manipulate phonological units?
√ - PhAB spoonerism subtest (Frederikson *et al.* 1997)
√ - PAT rhyme fluency subtest (Muter *et al.* 1997)

I Can the child articulate real words accurately?
X – Real word repetition subtest (Constable et al, 1997)
X – Real word repetition (Snowling)
√ - Aston index blending subtest – real Words (Newton and Thompson 1982)

J Can the child articulate speech without reference to lexical representations?
√ – Aston index blending subtest – nonwords (Newton and Thompson 1982)
X – Non-word repetition subtest (Constable et al, 1997)
XX - Non-words test (Snowling)

K Does the child have adequate sound production skills?
√ - Nuffield Motor assessment; Oral examination and DDK
Finds it hard to produce [ʃ]

L Does the child reject his own erroneous forms?
Inconsistently

Ben had good semantic knowledge and was aided by the use of pictures. His online motor programming skills were variable: when faced with more challenging non-words he performed at a lower level than one might expect for a child of his age (e.g. see the results of the Snowling Test, level J, Figure 8.1, Appendix 2b). However, online motor-programming is a relative strength when compared to his access of stored motor programmes.

2.2.3 Weaknesses

Ben seemed to have two core areas of difficulty: one on the input side and one on the output side of his speech processing profile. Input difficulties were mainly with his discrimination of closely related real words (level D) and non-words (level B). Ben performed variably on the discrimination tasks, for both real word and non-word items. On standardised tests such as the Aston index discrimination subtest (Newton and Thompson, 1982) he scored age-appropriately for both real and non-words. However, the more challenging items in Bridgeman and Snowling's (1988) test (see Appendix 2a) were problematic, and Ben scored several standard deviations below the mean for his age. This test requires children to distinguish between [st] and [ts] using a same / different paradigm with word pairs such as [fɪts] and [fɪst]. The rationale behind this procedure is that children with dyspraxic speech typically make errors in their sequencing of sounds, but the basis for these errors is thought to be not entirely attributable to output difficulties but also with input difficulties. Ben's difficulty with the Bridgeman and Snowling tasks suggests that sound sequencing - both for input and output - is problematic for him. From another point of view his poor performance on the test is not surprising if one considers that production of [st] is one of Ben's particular speech output difficulties.

Output difficulties were centred on his stored motor programmes where it seems that many 'frozen' motor programmes have not been updated, despite improved online motor processing, as illustrated by the BISCUIT example above. Ben found repetition of real and non-words hard: especially when these were longer, low frequency and more phonetically complex words.

It was hypothesised that his discrimination difficulties and 'frozen' motor programmes work together to affect his speech processing: If one is not hearing all the linguistic information encoded in a word, then one will not be able to create accurate motor programmes and produce these appropriately. From a developmental perspective, linguistic input is a prerequisite for linguistic output. Ben does have a history of input difficulties with level A (auditory perception) affected when he was younger. Although these problems with his hearing may now be resolved, the effect may be more lasting on his entire speech processing system. It is suggested that both auditory discrimination and motor programming must be addressed together in order for change to be brought about in Ben's speech processing. Two tasks were carried out to determine the relative contribution of Ben's auditory discrimination difficulties to his output difficulties.

Task A: Ben was given pictures of selected items from the Snowling repetition task (e.g. ESKIMO, SPAGHETTI and AMBULANCE, See appendix 2b). He was asked to name the pictures, and his productions compared with his speech productions from the repetition task. In a similar way his repetitions on the Constable et al. (1997) real word naming task were compared with his spontaneous picture naming abilities for these items. Ben had many difficulties with both the naming and the repetition task. However, on an item-by-item comparison it was clear that his difficulties were greater on the repetition task than on the naming task, suggesting that in the case of the former he is confused by the input he receives, unclear of the phonological representation he needs to select. In the case of the picture naming, having semantic knowledge aided him slightly in his retrieval of a motor programme. However, in the real word repetition task, Ben could also access semantic information to aid in selection of a motor programme, although he did not necessarily need to do this.

Task B: Another way of making comparisons between tasks involving input and those that do not, is through reading. Using a non-word reading task is one way of removing semantic knowledge and concentrating on the specific contributions of input *and* motor programming *vs*. motor programming only. Ben was given a list of 10 real and 10 non-words to read out. His performance on the non-word items was better (80% correct) than for the real word items (60% correct). However, comparison of these scores using an independent samples t-test indicated that the difference was not significant ($t(18)=-.949$, n.s). He was then given a spelling task in which he was shown pictures of words and asked to write the words, without these having been named. His performance on this task was better than for the dictation spelling task using the same set of words, but since the sample of items used was small statistically significant change could not be demonstrated.

2.3 Speech analysis

PACS (Grunwell, 1985) was carried out to provide information on Ben's speech production system. A summary of the findings is presented in Table 8.2.

Table 8.2
Summary of Ben's speech data at CA 8;8

Assessment	Comments	
Severity indices	PCC 86 % PVC 99 % PPC 90.3 %	
Phonetic inventory	Word initial position: All phonemes except [tʃ], [dʒ], [θ], [ʃ] Word medial position: All phonemes except [θ], [ʃ], [ʒ] Word final position: All phonemes except [tʃ], [θ], [ʃ], [ʒ]	
Stimulability	All phonemes except [ʃ]	
Phonological processes analysis (% use)	Developmental processes: Cluster reduction (30%); fronting of [tʃ], [dʒ] and [ʃ] (87.5%); gliding [r] to [w] (20%)	
Single word speech sample	[tiz] for CHEESE [sæm] for JAM [fʌm] for THUMB [fɪs] for FISH [weɪk] for RAKE	[bɜfdeɪ] for BIRTHDAY [bwɪs] for BRIDGE [ɛksɪməʊ] for ESKIMO [sæl] for SHELL [səʊk] for STROKE
Connected speech sample	[aʊmʊts] for HOW MUCH [aɪhæd.əlɪtəl] for I HAD A LITTLE [iʔgɒbwəʊkɪn] for IT GOT BROKEN [ɪ.wɜ.leɪfɔwɜk] for HE WERE LATE FOR WORK	

The severity of Ben's speech difficulties was estimated at two points before the intervention: at the start of the macro-assessment, and at the micro-assessment, carried out ~6 weeks later. PCC (percentage of consonants correct), PVC (percentage of vowels correct) and PPC (percentage phonemes correct) were used[19]. The difference between these scores at the two pre-intervention points was not a significant one indicating a stable pre-intervention baseline. The severity indices suggest that Ben's speech difficulties were very mild. Nevertheless, he did have some specific difficulties: [tʃ] was reduced to its stop component (e.g. [t̲iz] for C̲H̲EESE), [dʒ] was fronted to [s] or [d] (e.g. [s̲æm] or [d̲æm] for J̲AM), [f] was typically substituted for [θ] (e.g. [f̲ʌm] for T̲H̲UMB), and [ʃ] fronted to [s] (e.g. [fɪs̲] for FIS̲H̲). [r] was glided to [w] for ~20% of the time, e.g. [w̲eɪk] for R̲AKE. Ben was stimulable for each of these sounds in isolation, although [ʃ] was extremely hard for him and required many tries.

While Ben had generally mastered all consonant clusters, he found it difficult to produce [st] and [str] in all word positions typically deleting [t]. [str] (SIWI) was produced variably as [sw], [s] and [sr].

[19] following guidelines from Dodd (1995) and Shriberg et al. (1997c) and discussed in greater detail in Chapter 9 on intelligibility.

In terms of Dodd's (1995) sub-grouping, Ben is a child with delayed phonology. He was consistent in his speech production (approximately 90% consistency within each assessment session) and evidences errors which are typical of younger children.

2.4 Child interview and parent / teacher report

This part of the assessment aimed to gather impressions of Ben's speech from Ben himself, his class teacher, LSA and his parent. This information was used to assist with intervention planning and to evaluate the outcome of the intervention programme.

2.4.1 Child interview

Ben was interviewed in a semi-structured way to discover more about (1) his experience of speech and language therapy, (2) his perception and awareness of his own speech, (3) his perceptions of communication more generally, and (4) his attitudes to literacy (see Appendix 3). This interview procedure was carried out at two points in the study, midway through the intervention programme, when a rapport had been established, and at the completion of the intervention study at long-term follow-up. The results of the first interview are presented in Table 8.3, while the results of the second interview appear in the evaluation section (Section 6) for comparison. Table 8.3 shows that Ben enjoys speech and language therapy and had good insights into his communication and communication more generally.

Table 8.3
Summary of findings from Ben's first semi-structured interview following Phase I of intervention at CA 9;2

Area of questioning	Main findings	Examples of Ben's responses
Ben's experience of speech and language therapy	Enjoys therapy	"it's good"
• Present (comments on phase I)	Particularly enjoys games and drawing	"I like drawing. The train game is the best"
	Doesn't like the video and being recorded	"the video is a bit scary"
• Past	Can't remember	
Ben's perception and awareness of own speech	He enjoys talking but only to certain people	
	He likes listening	
	His speech has improved	"yeah (it has improved) but its hard to say how."
	He has been misunderstood quite often	
Ben's perceptions of communication more generally	Not everybody in the world speaks English. He knows some other languages.	"Lots of other languages, like Japanese, Chinese and American"
Ben's attitudes to literacy	Reading is very important for accessing information	"if you're learning about animals, you can bring in your animal book and read about them"
	Reading can be difficult but is easier than writing.	"hard words make reading hard."

2.4.2 Teacher report

Ben's class teacher and LSA jointly completed Bishop's (1998) CCC. The results of the checklist are presented in Table 8.4.

Table 8.4
Summary of the Children's Communication Checklist (CCC, Bishop, 1998) and Ben's performance on subscales

CCC subscale	Example of behaviours in each subscale	Ben's Score	Comments*
A. Speech output: intelligibility and fluency	Intelligibility; use of immature speech sounds; rate and fluency	24	Scores of 27 or below require further investigation; Ben's speech is an area of difficulty
B. Syntax	Grammatical errors, phrase length	29	Acceptable: Scores below 29 require further investigation
C. Inappropriate initiation	Ability to talk appropriately to different people; whether amount and nature of communication is appropriate for the situation	28	Ben's composite score for the Pragmatic subscales C-G = 152. Scores below 132 are considered indicative of pragmatic impairment.
D. Coherence	Ability to talk logically; make explicit information when needed	31	
E. Stereotyped conversation	Use of favoured phrases and topics; over-precise manner	30	
F. Use of conversational context	Understanding conversational rules; social appropriacy	30	
G. Conversational Rapport	Appropriacy of initiation and response to initiation of conversation; understanding and use of facial expression, gesture and eye-contact	33	
H. Social relationships	Friendships; interactions with children and adults	33	Acceptable: Scores of 24 or less require further investigation
I. Interests	Having very focused interests; prefers to do things alone or with others; interests in factual information	31	Acceptable: Scores of 28 or less require further investigation

* based on clinical guidelines from http://epwww.psych.ox.ac.uk/oscci/dbhtml/CCC/cccinstruct.htm

Ben's pragmatic skills are excellent. His greatest area of difficulty was with his speech. Bishop suggests for clinical purposes that children scoring less than 27 on the speech scale should be followed up with further investigations. Ben scored 24, and thus fell into this range. His syntactic score of 29 fell at the cut-off point at and below which Bishop considers a syntactic impairment to exist.

In order to provide further information about Ben's academic progress over the course of the intervention, his SATs results were obtained for the assessments carried out prior to intervention (CA 8;9). Ben obtained scores of 2A for numeracy, 3B for science and

3C for reading and writing. These scores are discussed in further detail in the evaluation of the intervention.

2.4.3 Parent report

Ben's father was concerned about Ben's speech, language and literacy at the start of the project. He observed that Ben sounded a little babyish at times, and notes that people often have to ask him to repeat what he has said. His father also had concerns about Ben's general academic progress and the fact that he is withdrawn and has few friends.

2.5 Further investigations

The assessment yielded a picture of Ben's strengths and weaknesses but it also raised some questions. These were investigated using further specific tasks, as outlined below.

(a) One key role of auditory discrimination in speech processing is in allowing an individual to distinguish between correct and incorrect production in their speech. Were Ben's speech production errors (partly or completely) due to the fact that he is unable to distinguish between his own error sounds and target productions? In order to answer this question, a discrimination test consisting of 50 items based on Ben's output errors was devised. Ben performed poorly on this task, unable to distinguish between phoneme pairs such as [tʃ] and [t]; [ʃ] and [s] in both real and non-word items, and in all word positions. It was concluded that Ben's auditory discrimination skills affect his speech production and should be addressed in intervention.

(b) Is there a link between Ben's spelling and speech difficulties? Is he able to spell words containing sounds that he finds hard to produce? Ben's teacher noted many of his speech errors in his spelling, but this required more systematic investigation. The Schonell spelling test (Newton and Thompson, 1982) was administered and results from this test qualitatively analysed. In addition, further items, incorporating Ben's speech production errors were presented to him in a dictation task. Table 8.5 compares spoken and written productions of Ben's error phonemes.

Table 8.5
Comparison of Ben's spoken and written productions

Target phoneme/cluster	Spoken production	Written production
/st/	[s]	st, sr, s
/str/	[s], [sw], [sr]	str, sr
/tʃ/	[t], [ts]	ch, t
/dʒ/	[dʒ], [s]	j, t, th
/θ/	[f]	th (for all real words) f (for all non-words)
/ð/	[θ]	th
/ʃ/	[s]	sh, s, omits
/r/	[r], [w]	r, w

In general the speech errors *were* replicated in his spelling, although with varying degrees of consistency, e.g. /θ/ was always correctly represented by the grapheme <th> in real words, /ʃ/ was variably represented as <sh>, often being omitted or represented by <s>.

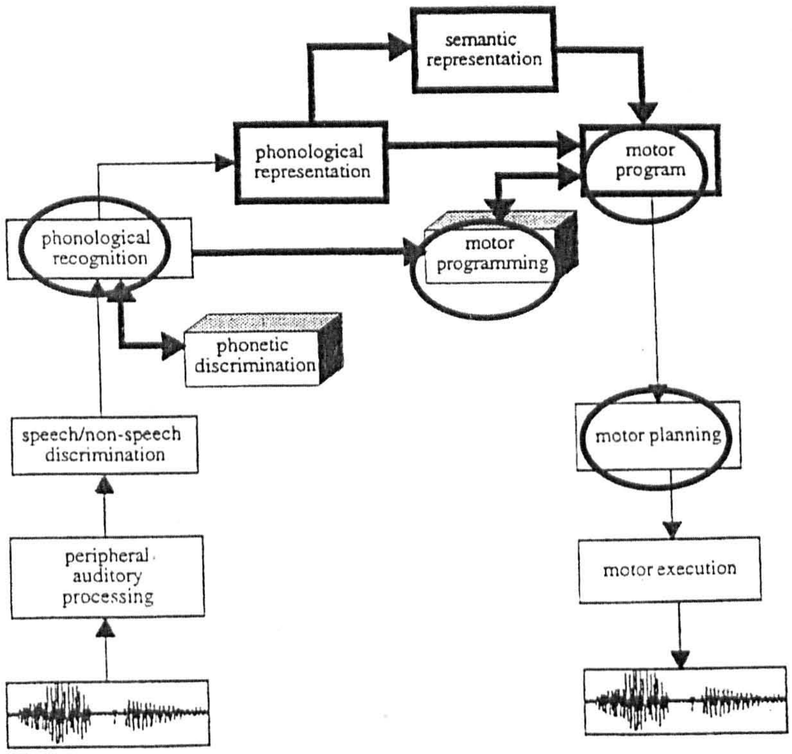
3. MACRO INTERVENTION PLANNING

Intervention planning focused on three main areas with each one giving direction to the work carried out. These included (1) a psycholinguistic rationale that aimed to answer the question: "What aspects of Ben's speech processing system should be worked on?" (2) a phonological rationale which aimed to answer the question: "Which aspects of the sound system should be treated?" and (3) a more general child-centred rationale which aimed to answer the question: "What other aspects important to the child should be taken into account? Each of these is discussed in the sections that follow.

3.1 Psycholinguistic rationale – What aspects of the speech processing profile should be worked on?

Ben's main deficits were mapped from the speech processing profile onto Stackhouse and Wells' (1997) speech processing model. Ben's main areas of difficulty are presented in Figure 8.2

Figure 8.2.
Speech processing model (from Stackhouse and Wells, 1997) showing Ben's main areas of difficulty at CA 8;11



Ben had difficulties with both input and output: discrimination of real words and non-words; storage and online creation of motor-programmes, as well as motor planning. These are all areas that intervention needed to address. Ben's difficulties with each of these parts of the model were not general. He was able to carry out many of these tasks efficiently, but it was with a small and specific set of phonemes that problems arose. The motor programme representations affect both his speech and his spelling, and intervention was required for both these areas[20]. Ben's online motor programming was a relative strength when compared to his stored motor programmes. As for all the children, Ben's intervention needed to carefully affect positive change in the areas of weaknesses, using the stronger areas to gently 'scaffold' change. Ben's intervention task hierarchy is presented in Table 8.6 and shows how the intervention was structured to move towards increasingly challenging tasks.

[20] A child with similar difficulties is described by Nathan and Simpson (2001).

Table 8.6
Ben's intervention task hierarchy

Task 1= easiest; 9 = most challenging	Description	Part of the speech processing system tapped
Task 1	non-word reading task	taps output: the relative strength of online motor programming and bypasses auditory discrimination
Task 2	real word reading task	taps output: online motor programming and/or stored motor programmes. Bypasses auditory discrimination
Task 3	listening and picture matching task	taps input: pictures are provided to give top-down support but bypasses output weaknesses
Task 4	listening and real word matching task	taps input: relies on phoneme-grapheme conversion and orthographic knowledge. Bypasses output, no picture support available
Task 5	non-word listening and word matching task	as above but non-word discrimination is more challenging
Task 6	real word listening and written output	taps input and written output
Task 7	non-word listening and written output	as above, but more challenging with non-words
Task 8	real word listening and repetition	taps input and spoken output
Task 9	non-word listening and repetition	as above, but more challenging with non-words

Early tasks in the hierarchy were designed with the aim of tapping one of the areas of weakness (i.e. either output or input) while later tasks draw on both these aspects. Each step in the hierarchy is designed to be increasingly more challenging for Ben, although the increments between tasks are small (e.g. Task 1 is a non-word reading task, Task 2 is the same task but slightly more challenging for Ben in its use of real words). This hierarchy has been designed to focus firstly on each of the weak points individually and to support them with relative strengths (e.g. pictures, online motor programming) and then to bring them together working on both input and output.

3.2. Phonological rationale - Which aspects of the phonological system should be targeted?

Ben's difficulties were summarised in section 2.3.1 based on the PACS analysis (Grunwell, 1985). His difficulties are all at a segmental level and limited to a small group of sounds which include the clusters /str/ and /st/ as well as /ʃ/, /dʒ/, /tʃ/ and /θ/. Because of Ben's age it was decided that intervention should aim to address as many of these speech sounds as possible in order to be maximally efficient. Phonemes were selected with a view to carrying out minimal work to achieve maximal generalisation. The three phonemes /ʃ/, /tʃ/ and /θ/, and the cluster /st/ were selected as intervention targets. It was hypothesised that working on this set of items would result in generalisation to other problematic sounds. For example, the cluster /st/ might lead to generalisation to the 3 part cluster /str/. There is some evidence that targeting 3 part consonant clusters can result in widespread generalization to two part consonant clusters (Gierut and Dinnsen, 1987). Would the reverse be true? Another claim to be investigated is that working on [s]+stop clusters (such as [st]) does not result in generalization to other clusters although working on other clusters does (Gierut, 1999).

Addressing the other three targets /ʃ/, /tʃ/ and /θ/ might result in more consistent production of the voiced counterparts of these phonemes, i.e. /ʒ/; /dʒ/ and /ð/. There is some evidence that treatment of one representative aspect of a sound category can facilitate improvement across that category (within class generalization). This has been documented for place, manner and voicing of production, e.g. treatment of fricatives [s] and [θ] enhanced changes in other untreated fricatives (Costello and Onstine, 1976). This type of generalization is thought to be influenced by the relationship that exists between sounds. The fact that children seem to generalize across sounds that have common features is some indication that these groupings have a psychological validity.

As for all the children, the concept of productive phonological knowledge (PPK) (Gierut and Dinnsen, 1987) was invoked. The four targets /st/, /ʃ/, /tʃ/ and /θ/ were considered in the light of Ben's PPK. /ʃ/ is a PPK type 6 phoneme, about which Ben has no knowledge and which is produced incorrectly in all word positions. Phonemes in PPK Type 4 are defined as being produced correctly in one or more word positions and consistently in error in others. The remaining three targets were considered to fall in this group since Ben was able to produce them in some word positions, but never in others.

3.3. Child-centred rationale – What other aspects important to the child should be taken into account?

Ben is a quiet boy who is sometimes teased by other children. He seemed to have insight into his difficulties and was motivated to change his speech. Intervention aimed to build Ben's confidence, giving him opportunities to display his talents, e.g. in art. Because of his high levels of insight and motivation he was regarded as a partner in therapy with the nature and goals of activities made explicit at each stage.

4. MICRO INTERVENTION PLANNING

Ben received a total of 36 hours of intervention. This was subdivided into 4 equal phases with each one addressing a specific target sound. Re-assessment was carried out following each intervention phase in order to evaluate the effects of therapy over the course of the programme. Four lists of stimuli were devised with each list representing one of the four treatment targets. The requirements for each of the 4 treatment lists are set out below

(a) each list to consist of 10 monosyllabic words

(b) each list to represent a different phoneme or cluster: list A= /st/; list B = /ʃ/; list C = /θ/, list D = /tʃ/

(c) each of the lists to have half the items with the targets in word initial position, and the other 5 with the target in word final position

(d) items to be matched across the groups by Thorndike-Lorge written frequency (from the MRC Psycholinguistic database[21]) and for spelling irregularities

The four treatment stimuli lists are presented in Table 8.7.

Table 8.7
Ben's four treatment stimuli lists

		List A /st/	List B /ʃ/	List C /θ/	List D /tʃ/
1	Word initial target	STACK	SHEET	THAW	CHAIR
2		STAY	SHELL	THIN	CHOKE
3		STEAL	SHIP	THORN	CHAP
4		STOLE	SHOCK	THANK	CHILL
5		STUCK	SHORE	THICK	CHEEK
6	Word final target	PAST	DISH	MOTH	CATCH
7		MIST	CASH	MOUTH	COACH
8		TEST	PUSH	PATH	MATCH
9		NEST	BASH	DEATH	PEACH
10		GUST	LASH	BATH	BENCH

The task hierarchy in Table 8.6 shows that for each phoneme group, real word and non-word tasks, were carried out. The real word task involved the words shown in Table 8.7. For each of these items a matched non-word item was created by keeping the target sound and altering the medial vowel and remaining consonant segment to produce a phonotactically acceptable

[21] www.psy.uwa.edu.au/mrcdatabase/uwa_mrc.htm

non-word (STACK -> STIP). These non-words are presented in Table 8.8 together with the real word targets from which they were derived.

Table 8.8
Ben's four treatment stimuli lists showing real words and matched non-word stimuli

		List A /st/		List B /ʃ/		List C /θ/		List D /tʃ/	
1	Word initial target	STACK	[stip]	SHEET	[ʃɔp]	THAW	[θiz]	CHAIR	[tʃɑk]
2		STAY	[stɔ]	SHELL	[ʃɪg]	THIN	[θɒs]	CHOKE	[tʃup]
3		STEAL	[stɔg]	SHIP	[ʃæn]	THORN	[θɑb]	CHAP	[tʃɪd]
4		STOLE	[stɑb]	SHOCK	[ʃʌb]	THANK	[θɪp]	CHILL	[tʃəʊb]
5		STUCK	[stɒn]	SHORE	[ʃim]	THICK	[θud]	CHEEK	[tʃɒs]
6	Word final target e	PAST	[dɛst]	DISH	[pɪʃ]	MOTH	[sæθ]	CATCH	[bɑtʃ]
7		MIST	[kist]	CASH	[bɛʃ]	MOUTH	[gaʊθ]	COACH	[fitʃ]
8		TEST	[maɪst]	PUSH	[fɒʃ]	PATH	[wəʊθ]	MATCH	[weɪtʃ]
9		NEST	[tʌst]	BASH	[nʌʃ]	DEATH	[tɛθ]	PEACH	[bɛtʃ]
10		GUST	[bæst]	LASH	[vaʃ]	BATH	[dəʊθ]	BENCH	[sutʃ]

Each of the stimuli lists was addressed in successive intervention phases. The order for the intervention was randomly chosen. /st/ was addressed in intervention phase I, /ʃ/ in intervention phase II, /θ/ in the third phase of intervention and the final phase of intervention focused on /tʃ/. Each of these intervention phases consisted of 9 sessions with each session involving the tasks outlined in Table 8.6 for the words in question and taking approximately one hour.

In order to evaluate generalisation effects, further lists of untreated stimuli were created. These are presented in Table 8.9 and were chosen according to the following criteria.

(a) For each of the four treatment stimuli (/st/, /ʃ/, /tʃ/, /θ/) 10 words were selected with the treated sound in word-initial position. They were monosyllabic words matched to the treated items in terms of the Thorndike-Lorge written frequency and for spelling irregularities. These ***matched*** words with target phonemes in ***word-initial*** position were chosen to evaluate within item generalisation.

(b) For each of the four treatment stimuli (/st/, /ʃ/, /tʃ/, /θ/), a further 10 items were selected with the treated sound in word-final position. They were also monosyllabic words matched to the treated items in terms of the Thorndike-Lorge written frequency and for spelling irregularities. These ***matched*** words with target phonemes in ***word-final*** position were chosen to evaluate within item generalisation.

(c) For each of the four treatment stimuli (/st/, /ʃ/, /tʃ/, /θ/), a further set of 10-20 items was selected that contained the ***'linked' sound***, i.e. either the voiced counterparts for /ʃ/, /tʃ/, /θ/, or in the case of /st/, the three-part cluster /str/, used to observe the effects of generalisation. The size of the groups varied because /ʒ/, for example, occurs word-finally only and with low frequency. These were words matched in terms of frequency of usage, and containing the control phonemes in word-initial and / or final position, depending on the sound in question. These words were chosen to evaluate within class generalisation.

(d) For each of the four treatment stimuli (/st/, /ʃ/, /tʃ/, /θ/), a set of 10 ***non-words*** was created which contained the target in word initial (5 items) and word final position (5 items). These words were chosen to evaluate any changes which had been brought about in online processing.

Table 8.9
Ben's untreated control stimuli

	Matched words with target in word initial (WI) position	Matched words with target in word final (WF) position	Linked sound used to monitor within class general-isation	Words with linked sound	Non-words with target in WI and WF position
[st]	STAB	BEST	[str]	STRAP	[stug]
	STAFF	CAST		STRAW	[stæz]
	STAIN	COST		STRIKE	[stɛb]
	STALE	DUST		STREAM	[stuv]
	STALL	LIST		STREET	[stauf]
	STAR	FIST		STRING	[wɪst]
	START	MAST		STRIP	[jɒst]
	STEAM	PEST		STRIPE	[pɔst]
	STEEP	BOOST		STROKE	[deɪst]
	STEM	VEST		STRONG	[fust]
[ʃ]	SHOOT	BLUSH	[ʒ]	BEIGE	[ʃeɪg]
	SHADE	MARSH		CASUAL	[ʃub]
	SHAKE	BUSH		MEASURE	[ʃɑn]
	SHAME	MASH		MIRAGE	[ʃɒf]
	SHAPE	SMASH		USUAL	[ʃɪl]
	SHARE	WISH		VISION	[wɛʃ]
	SHIRT	FISH		COLLAGE	[miʃ]
	SHARP	FLASH		GARAGE	[jæʃ]
	SHINE	FLUSH		PLEASURE	[hɪʃ]
	SHOE	WASH		UNUSUAL	[feɪʃ]

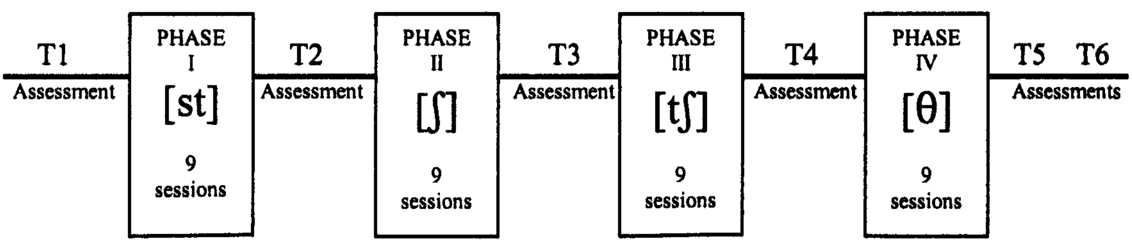
Table 8.9 *cont.* Ben's untreated control stimuli

[θ]	THIEF	BOTH	[ð]	THEM	SMOOTH	[θæb]
	THING	FAITH		THEN	BATHE	[θɛf]
	THINK	TOOTH		THAT	SOOTHE	[θɔg]
	THIRD	TEETH		THEY	CLOTHE	[θaʊk]
	THUD	WORTH		THOSE	LOATHE	[θeɪm]
	THUMB	WITH				[pɒθ]
	THEME	NORTH				[ləʊθ]
	THUG	FOURTH				[kɛθ]
	THUMP	SOUTH				[biθ]
	THIGH	BIRTH				[waʊθ]
[tʃ]	CHAIN	LUNCH	[dʒ]	JOIN	FUDGE	[tʃɒg]
	CHARM	BEACH		JOKE	BARGE	[tʃɛs]
	CHASE	DITCH		JUMP	LARGE	[tʃeɪb]
	CHILD	BUNCH		JACK	BULGE	[tʃɪb]
	CHEAP	PITCH		JAIL	CAGE	[tʃɔf]
	CHIN	PINCH		JAM	LEDGE	[sitʃ]
	CHIP	FETCH		JOG	WAGE	[mitʃ]
	CHOP	MARCH		JOB	HEDGE	[hɔtʃ]
	CHEESE	PATCH		JET	EDGE	[keɪtʃ]
	CHECK	HATCH		JERK	HUGE	[futʃ]

Figure 8.3 shows the design of the intervention. Baseline evaluation took place prior to the intervention at T1, and then following each of the four phases of intervention, in accordance with a multiple baseline design. Each phase comprised 9 sessions, i.e. working through the 9 tasks of the task hierarchy focusing on one particular target. On completion of the programme (T5), re-assessment took place, and at T6, long-term follow-up evaluation took place. Each of these micro assessments involved the following tasks:

(a) Picture naming of treatment stimuli words in Table 8.7
(b) Repetition of untreated, matched non-words in Table 8.8
(c) Picture naming or repetition of all untreated, control words in Table 8.9
(d) Spelling of both real and non-words from dictation
(e) Auditory discrimination task using 'same / different ' paradigm to distinguish between all stimuli words and closely related words e.g. are these the same or different: STALE / SALE?

Figure 8.3
The design of Ben's intervention programme



The following questions were asked:

(a) Is the intervention strategy effective? If so there should be improvements in Ben's speech production of treated items beyond chance level. If the intervention is effective, does the success of the intervention vary across the four sounds targeted, and why?

(b) Does generalisation extend to the untreated matched control stimuli? If within-item generalisation is found, what are the patterns observed? Is generalisation greater for some of the targets than others and how does this inform our knowledge about the relationship between the sounds?

(c) Does generalisation extend to the untreated 'linked' control stimuli? If within-class generalisation is found, what are the patterns observed? Is generalisation greater for some of the phonemes/clusters than others and how does this inform our knowledge about the relationship between the sounds?

(d) Is improvement noted in Ben's repetition of non-words? If so, this would suggest that his online motor programming had been effectively altered.

(e) How does the intervention affect Ben's written representations of words? Are improvements beyond chance level noted for treated items and /or untreated controls, and how does this inform our knowledge of the speech-spelling link? If the intervention is effective for spelling, does the success of the intervention vary across the four sounds targeted, and why?

(f) Does Ben's auditory discrimination ability improve over the course of intervention? What is the pattern of change observed and how does this fit in with the changes observed for speech and spelling?

5. INTERVENTION

5.1 Overview of intervention

Intervention consisted of 4 consecutive phases with each phase focussing on a particular target sound. Each phase consisted of 9 sessions of approximately one-hour duration, i.e. one session for each task in the task hierarchy as shown in Table 8.6. There was a total of 36 intervention sessions. The sessions were carried out on a twice-weekly basis in Ben's school in a quiet room with only him and the therapist present. Ben was 8;10 at the start of the intervention itself and was 9;7 on completion of the final phase of intervention.

5.2 Intervention report

Each phase centred round a phoneme or cluster. Sessions are outlined in Table 8.10 together with notes from each session.

Table 8.10
Summary of Ben's intervention sessions

Session number	Task	Example of stimulus	Comments
Phase I [st]			
1	non-word reading task	[stip]	Ben was able to read all 10 non-words correctly. Made use of whispered verbal rehearsal, and self-corrected [st] (reduced to [s]) when doing this.
2	real word reading task	STACK	All words correctly produced both WI and WF.
3	listening and picture matching task	STACK	Able to do quickly and accurately.
4	listening and real word matching task	STACK	75% of items correct at first try. Some of the items he was not able to find and other times he was confused by the foils.
5	non-word listening and word matching task	[stip]	Found this task more challenging with the non-words. Needed some practice to become confident.
6	real word listening and written output	STACK	No difficulties. (100% correct)
7	non-word listening and written output	[stip]	More challenging for Ben than with the real words, but able to write all appropriately by end of session.
8	real word listening and repetition	STACK	Excellent productions – no errors.
9	non-word listening and repetition	[stip]	Excellent productions – no errors.
Phase II [ʃ]			
1	non-word reading task	[ʃɔp]	He read the words with difficulty and needed encouragement to get the correct lip and tongue positioning for [ʃ].
2	real word reading task	SHEET	Much practice needed. Achieved 70% correct by completion of session.
3	listening and picture matching task	SHEET	A very easy task for Ben (100% correct).
4	listening and real word matching task	SHEET	A very easy task for Ben (100% correct).
5	non-word listening and word matching task	[ʃɔp]	No difficulties in finding the words. He achieved 100% correct by end of session.
6	real word listening and written output	SHEET	Slightly more challenging than previous task. (70% accuracy achieved)
7	non-word listening and written output	[ʃɔp]	Excellent phoneme-grapheme conversion (90%).
8	real word listening and repetition	SHEET	[ʃ] is easier for him WF than WI. Inconsistent productions (40%).
9	non-word listening and repetition	[ʃɔp]	Non-words are easier to produce than real words but still challenging for him (60% with support).
Phase III [θ]			
1	non-word reading task	[θiz]	Excellent productions – no errors.

Table 8.9. ***Cont.*** Summary of Ben's intervention continued

2	real word reading task	THAW	Excellent productions – no errors.
3	listening and picture matching task	THAW	A very easy task for Ben. Achieved 100%
4	listening and real word matching task	THAW	A very easy task for Ben. Achieved 100%
5	non-word listening and word matching task	[θiz]	A very easy task for Ben. Achieved 100%
6	real word listening and written output	THAW	Good [θ] representations as appropriate; experienced most difficulty with medial vowels.
7	non-word listening and written output	[θiz]	As for real words.
8	real word listening and repetition	THAW	Excellent productions – no errors.
9	non-word listening and repetition	[θiz]	Excellent productions – no errors.
Phase IV /tʃ/			
1	non-word reading task	[tʃɑk]	An easy task for Ben (90%).
2	real word reading task	CHAIR	90% accuracy achieved.
3	listening and picture matching task	CHAIR	100% accuracy achieved.
4	listening and real word matching task	CHAIR	This task was more challenging for Ben and he required some practise (60%).
5	non-word listening and word matching task	[tʃɑk]	Another fairly challenging task for Ben (60%).
6	real word listening and written output	CHAIR	Good spelling noted (70%)
7	non-word listening and written output	[tʃɑk]	Good spelling noted (70%)
8	real word listening and repetition	CHAIR	High level of accuracy noted (90%).
9	non-word listening and repetition	[tʃɑk]	High level of accuracy noted (90%).

6. EVALUATION

This section focuses on the outcome of Ben's intervention programme. Section 6.1. is a micro evaluation of the intervention study, aiming to look at the specific changes in treated stimuli and untreated control items outlined in Section 4. The section starts with an overview of the micro evaluation (6.1.1), before considering speech (6.1.2), spelling (6.1.3) and auditory discrimination (6.1.4) in turn. Section 6.15 summarises the findings from the micro evaluation. Section 6.2 provides a macro analysis of the intervention, aiming to outline broader benefits in the following areas: standardised language assessment (6.2.1), speech profiling in a psycholinguistic framework (6.2.2), speech analysis (6.2.3), and child interview and teacher / parent report (6.2.4). The section concludes with a summary of findings from the macro level (6.2.5).

6.1 Micro evaluation

Ben was reassessed at periodic intervals during the intervention study using a multiple baselines design. Figure 8.3 shows the six points (T1 – T6) at which he was assessed. The micro evaluation involved the following tasks:

(a) Picture naming of treatment stimuli words in Table 8.7
(b) Repetition of untreated, matched non-words in Table 8.8
(c) Picture naming or repetition of all untreated, control words in Table 8.9
(d) Spelling of both real and non-words from dictation
(e) Auditory discrimination task using 'same / different ' paradigm to distinguish between all stimuli words and closely related words e.g. are these the same or different: STALE / SALE?

The results for these assessments are described below.

6.1.1 Overview

Table 8.11 gives an overview of Ben's progress on treated and untreated stimuli by comparing the percentage of target sounds correct in his speech, spelling and auditory discrimination at pre-intervention assessment (T1) with scores obtained on completion of the programme at T5 (short-term follow-up), and at T6 (long-term follow-up). The scoring procedure focussed specifically on the target sounds, not on the remainder of the word. One point was awarded for each correct target sound (i.e. /ʃ/, /θ/ and /tʃ/, and the cluster /st/). Raw scores were converted into percentages.

A two-way mixed between-within subjects ANOVA was conducted. There was a statistically significant main effect for time for both speech [$F (5, 145) = 11.746, p< .001$] and spelling [$F (5, 145) = 9.862, p< .001$]. Both Ben's written and spoken production of the targeted sounds had change over the time course of the intervention programme. The effect size for speech (eta squared = .276) was slightly greater than that for spelling (eta squared = .243), but both are large effects (Cohen, 1988). For both speech and spelling, an interaction effect was found for time/stimuli group [$F (5, 145) = 5.517, p< .001$ (speech) and $F (5, 145) = 7.314, p< .001$ (spelling)] suggesting that the change occurring over time was different when comparing the treated words with the matched, untreated words. Greater change occurred for the treated items while generalisation to the untreated items resulted in less change overall.

Table 8.11
Overview of Ben's speech, spelling and auditory discrimination of stimuli words pre- and post-intervention

	T1 Pre-intervention % of target sounds correct**		T5 Post-intervention % of target sounds correct**		T6 Post-intervention % of target sounds correct**	
	Treated	Untreated matched controls	Treated	Untreated matched controls	Treated	Untreated matched controls
Speech: (*mean*)	*(40)*	*(48.75)*	*(62.5)**	*(52.5)*	*(70)**	*(72.5)** +
/st/	80	95	100	95	90	98
/ʃ/	0	0	10	0	10	18
/θ/	50	50	100*	70*	100	96+
/tʃ/	30	50	40	45	80+	78.3+
Spelling: (*mean*)	*(80)*	*(80)*	*(95)**	*(90)**	*(90)**	*(87.75)**
/st/	100	80	100	100	100	98
/ʃ/	100	95	100	95	90	70*+
/θ/	100	70	100	75	70*+	88
/tʃ/	20	75	80*	90	100*+	95*
Auditory discrimination: (*mean*)	*(72)*	*(73.3)*	*(79)*	*(71.47)*	*(77.15)*	*(73.82)*
/st/ e.g. NEST V. NESS	64	76.6	84*	83.3	100*	83.3
/ʃ/ e.g. SHOCK V. SOCK	88	86.6	92	82.7	92	90
/θ/ e.g. THIP V. FIP	48	40	44	43.3	40	40
/tʃ/ e.g. CHID V. SID	88	90	96	76.6	76.6+	82

** The scoring procedure focussed specifically on the target sounds, not on the remainder of the word. One point was awarded for each correct target sound (i.e. [ʃ], [θ] and [tʃ], and the cluster [st]). Raw scores were converted into %.
* paired with T1 results (p<.05) + paired with T5 results (p<.05)

Paired samples t-tests were carried out to compare performance on stimuli lists at two points in time. In terms of speech, it was found that Ben's production of the treated stimuli had improved significantly from T1 to T5 and from T1 to T6 (t(79)=-5.592, p<.05), although not from T5 to T6 after intervention ceased. For the untreated items, significant improvements were noted when comparing T1 with T6 (t(79) = -4.222, p<.05), and T5 with T6 (t(79)= -3.414, p<.05) showing that overall the intervention was effective and that the greatest gains were made after intervention had ceased, between the follow-ups.

In terms of speech production for individual sounds, it can be seen that Ben's production of /ʃ/ did not change significantly between T1 and the follow-up assessments at T5 and T6, despite intervention. Similarly, significant gains were not made for /st/ which seemed to be approaching ceiling at the start of the intervention. Ben seemed to have made gains with this sound between the initial macro assessment and the baseline measures at T1.

For /tʃ/, no significant gains were noted between T1 and T5, but the improvement occurring from T5 (short-term follow-up) to T6 (long-term follow-up) was significant ($t(39) = -5.099$, $p < .05$) for both the treated items and the matched controls. Significant gains were noted for production of /θ/ when comparing scores at T1 and at T5 ($t(39) = -4.583$, $p < .005$). Further gains were noted for the untreated controls at T6 ($t(19) = -2.597$, $p < .005$) by which point the treated sounds remained at ceiling.

Spelling performance was significantly better than speech performance. Spelling scores at T1 were significantly higher than those for speech ($t(318) = -4.551$, $p < .001$). They remained higher at T5 ($t(318) = -6.041$, $p < 001$) and T6 ($t(318) = -3.795$, $p < 001$). Ben's spelling of the treated words improved significantly from T1 to T5 ($t(79) = -5.646$, $p < .005$), and T1 to T6 ($t(79) = -5.132$, $p < .005$). The same pattern of change was noted for the untreated items with improvement from T1 to T5 ($t(79) = -3.549$, $p = .001$), and T1 to T6 ($t(79) = -3.359$, $p = .001$). For individual sounds, it can be seen that as for speech, /st/ seemed to be approaching ceiling at the start of the intervention and no significant changes were noted. /ʃ/ was also approaching ceiling at T1 and scores were maintained at T5. Again, it seemed as if Ben had improved in his spelling between the initial macro assessment and the baselines measures at T1 (for example Table 8.5). At T6, it was found that performance on the matched controls containing this sound had significantly declined ($t(39) = 2.912$, $p < .05$). Declines were also noted in the longer term for /θ/. Ben achieved high levels of accuracy with this phoneme in general, but at T6 assessment a significant decline in his performance on the treated words was noted from the previous assessments ($t(19) = 4.088$, $p < .001$). These declines in his spelling performance suggest that his spelling skills may not be as stable and robust as they seem at first glance. There was a significant improvement in Ben's written representation of words incorporating /tʃ/ following intervention for the treated words ($t(19) = -5.339$, $p < .001$) at T5 and further gains at T6 ($t(19) = -2.179$, $p < .05$). His performance on the untreated /tʃ/ words was initially higher, leaving less room for gains. However, the difference between his T6 and T1 scores for the untreated items was also significant ($t(39) = -2.726$, $p < .05$).

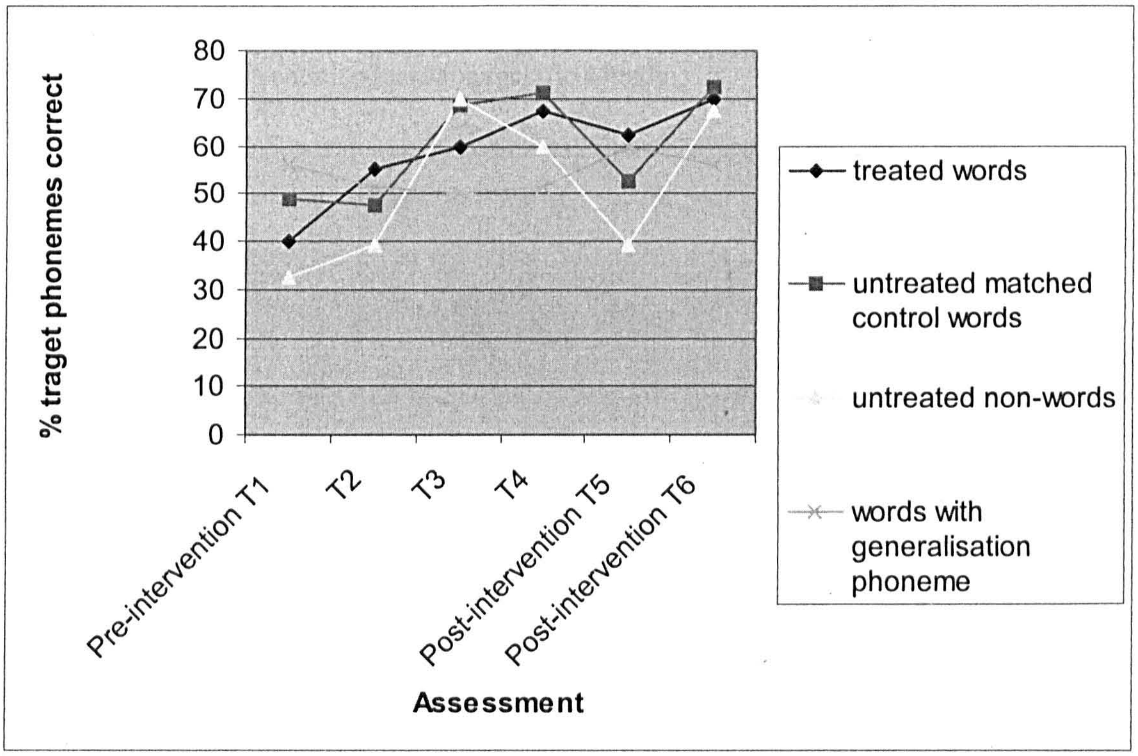
Results for auditory discrimination showed no significant changes over time. Overall, Table 8.11 shows that Ben's response to the intervention was variable. The following sections provide more details of these speech, spelling and auditory discrimination results.

6.1.2 Speech

Figure 8.4 shows the changes occurring in Ben's speech over the course of intervention from T1 (pre-intervention) to T6 (long-term follow-up), by stimulus type.

Figure 8.4

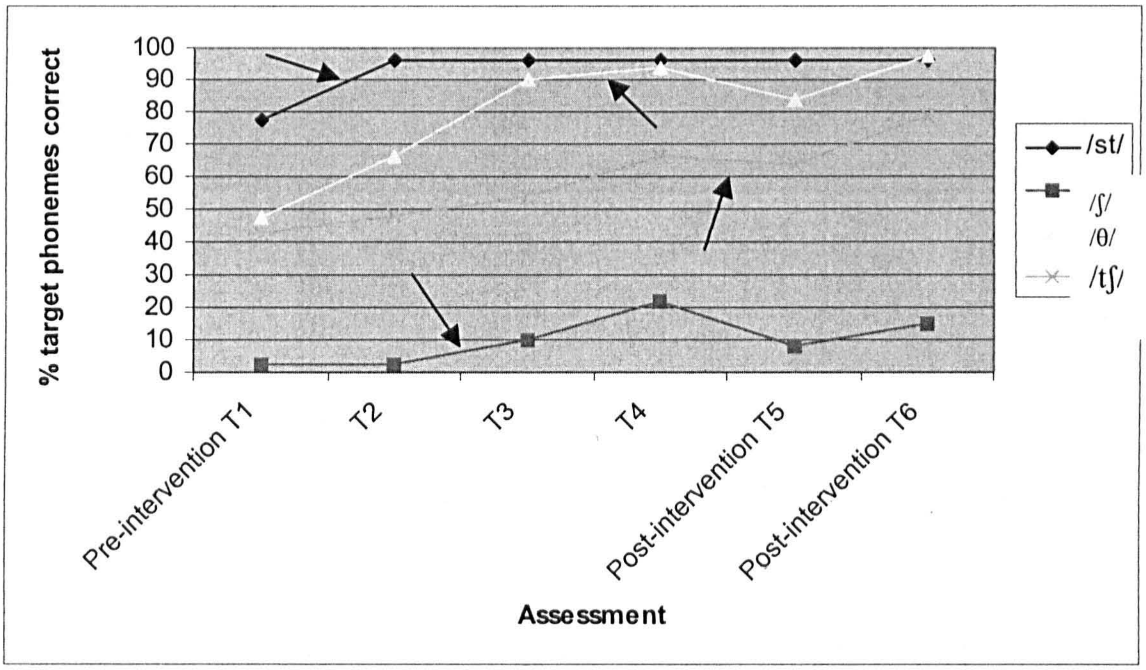
Comparison of Ben's stimuli groups over the course of intervention: speech



Ben made steady gains in his speech production of treated stimuli, although this was not 100% accurate by the completion of intervention. It has been previously noted that the change in performance on treated items from T1 to T6 was a significant one ($t(79) = -5.592$, $p<.05$). Untreated matched controls made some gains during the intervention with the greatest gains made after the second phase of intervention and again after the intervention-free phase between follow-ups. Again, it has been noted that this change in performance on untreated matched items from T1 to T6 was a significant one ($t(79) = -4.222$, $p<.05$). The pattern of change observed for the non-words is also a significant one, based on comparisons of performance at T1 and T6 ($t(39) = -3.122$, $p<.005$). Across the course of intervention, non-word scores revealed a peak of 70% accuracy after the second phase of assessment, with this falling to levels similar to those pre-intervention at T5, and then approximating 70% again at T6. The turbulent nature of changes in non-word production may reflect the fact that Ben's online motor programming was being altered in some way. Words which contained a closely-related sound target (e.g. voiced phonemes and another /s/ cluster) were also investigated. These words did not change significantly over the course of the programme suggesting that generalisation to other sounds was limited, and that the links between the target sounds and these items may not be strong.

Figure 8.5 shows changes in Ben's speech production over the course of intervention by sound groups.

Figure 8.5
Comparison of Ben's stimuli sounds over the course of intervention: speech
Arrows indicate intervention phases for specific sounds



Ben produced the four sounds with varying degrees of success both initially and after the intervention. /st/ was the cluster focussed on in phase I of intervention. This cluster was accurately produced at T1. He seemed to have made progress with this sound between macro and micro assessments. He responded well to the intervention, and at all subsequent follow-up assessments was able to maintain a 96% level of accuracy. The change from T1 to T6 represents a significant gain ($t(59) = -3.291$. $p<.005$). The sound addressed in phase II was /ʃ/. This was a more challenging sound for Ben. He made some progress after the specific intervention phase targeted at that sound, and in the period following the intervention. A significant gain was made for this sound when contrasting T1 and T4 results ($t(59) = -2.175$. $p<.05$) but not overall when comparing T1 and T5, and T1 and T6. The third phase of intervention addressed /θ/. Statistically significant progress was made when comparing results from T1 and T6 ($t(59) = -7.429$. $p<.001$). Much of this change was made in the initial two phases of intervention which did not directly address this sound. Further progress was noted in the phase of intervention that focussed specifically on the sound, with

Ben approaching ceiling on the assessment at the end of this phase. He was able to maintain these gains at follow up. The final phoneme addressed was /tʃ/. This phoneme showed steady improvement in the earlier phases of intervention, and was found to be continuing to improve at the long-term follow-up. Again, T1 and T6 comparisons reveal change that is statistically significant ($t(59)=-5.077$, $p<.001$). Table 8.12 gives a breakdown of results for each of the sound groups and in terms of the type of stimuli.

Table 8.12
Breakdown of Ben's speech results by stimuli type and sound category

		T1 Assessment % items correct	T2 Assessment % items correct	T3 Assessment % items correct	T4 Assessment % items correct	T5 Assessment % items correct	T6 Assessment % items correct
Treated words	[st]	80	100	100	100	100	90
	[ʃ]	0	0	10	10	10	10
	[θ]	50	60	80	100	100	100
	[tʃ]	30	50	60	60	50	80
Treated non-words	[st]	90	90	80	100	80	90
	[ʃ]	10	0	10	0	50	0
	[θ]	30	60	80	100	90	100
	[tʃ]	50	50	60	40	100	100
Untreated matched words							
	[st]	100	100	100	100	100	98
	[ʃ]	10	20	30	20	0	18
	[θ]	80	80	100	100	80	96
	[tʃ]	60	70	90	100	90	78
Untreated words with target in WF position							
	[st]	90	100	100	100	90	100
	[ʃ]	10	10	20	10	0	0
	[θ]	20	40	80	80	60	80
	[tʃ]	40	30	30	60	0	60
Untreated non-words							
	[st]	40	60	90	80	100	100
	[ʃ]	10	40	40	50	10	10
	[θ]	40	60	100	100	90	100
	[tʃ]	50	50	40	60	70	60
Words with generalisation sound	[st] [str]	60	40	30	20	40	0
	[ʃ] [ʒ]	10	10	10	20	10	40
	[θ] [ð])	60	70	70	80	100	100
	[tʃ] [dʒ]	70	70	100	80	70	70

It is interesting to note again that /st/ was a cluster that Ben seemed to have acquired prior to intervention: his scores in most of the word categories were approaching ceiling. /st/ was linked to the 3 part cluster /str/. Ben still experienced difficulties in producing /str/ on the completion of the programme, and his score had decreased to 0%. This cluster is one that is acquired relatively late in normal development (Mcleod, van Doorn and Reed, 1997). Although the intervention brought about changes in Ben's production of /ʃ/, his overall accuracy when attempting this sound, remained low. For this sound, he achieved relatively greater success with the non-words: both treated and untreated. The success with non-words may be due to the fact that it is easier to create a new motor programme rather than revise an existing one. /ʃ/ was linked to its voiced counterpart /ʒ/, and there was some improvement noted for this phoneme from 10% (T1) to 40% (T6).

For /θ/, some progress was observed for the treated words as well as the untreated items. /θ/ was linked to /ð/, its voiced counterpart, for which improvement was also noted. At the completion of the intervention, /ð/ was produced with a 100% accuracy. /tʃ/ was found to improve for many of the word categories, although production of this sound seems very variable. Treated non-words were more accurately produced than the real-words; untreated matched words were more accurate than the treated words; word-finally Ben's performance seemed very unstable with this phoneme ranging from 60% accuracy to 0% accuracy at the following assessment. For the linked phoneme /dʒ/, there were some gains during the intervention phases, but ultimately no change from T1 to T6.

Qualitatively, Ben's speech changed over the course of the intervention. Table 8.13 gives examples of the different patterns of change noted for the treated words. Six patterns of change were noted. These were:

(1) ***Erroneous production – no change.*** Over intervention Ben's production of these words did not change for the target consonant. He was never able to produce these words accurately – or differently, e.g. SHIP was always produced as /sɪp/ (See items 1 and 2 in Table 8.13).

(2) ***Correct production – no change***. These were words that Ben was able to produce correctly throughout the evaluations. Examples include items numbered 3-7 in Table 8.13, e.g. THIN was correctly produced at all times.

(3) ***Inconsistent changes***. Items in this category were in a state of flux with Ben using 'trial and error' in his realisation of the targets. Items 8 and 9 are examples of this group, e.g. CATCH was produced as [kæt], [kætʃ] and [kæts].

(4) ***'Model' items.*** These items responded to the intervention in the way which one aims for in a multiple baseline design. They were incorrect prior to their own

specific intervention phase (e.g. [sæk] for STACK) but following intervention they were accurate, remaining accurate at subsequent evaluations. Items 10-12 in Table 8.13 are examples of this pattern.

(5) ***'Premature' items.*** These words are ones which started out inaccurate, but were accurately produced before their specific intervention phase. These are words which may have improved without intervention or may have changed because of effects of the overall intervention programme, e.g. Items 13-17 in Table 8.13 such as CHOKE which was quickly modified from [tsəʊk] to an accurate production.

(6) ***'Delayed' items.*** These words were accurately produced only some time after intervention had targeted them. At the evaluation post-intervention they were unchanged, but the effects of intervention were delayed with a change to more accurate realisations occurring in a delayed fashion. An example of this group is item 18 in Table 8.13, the target SHORE is correct only at T5 and T6.

Table 8.13
Examples of qualitative changes in Ben's speech production

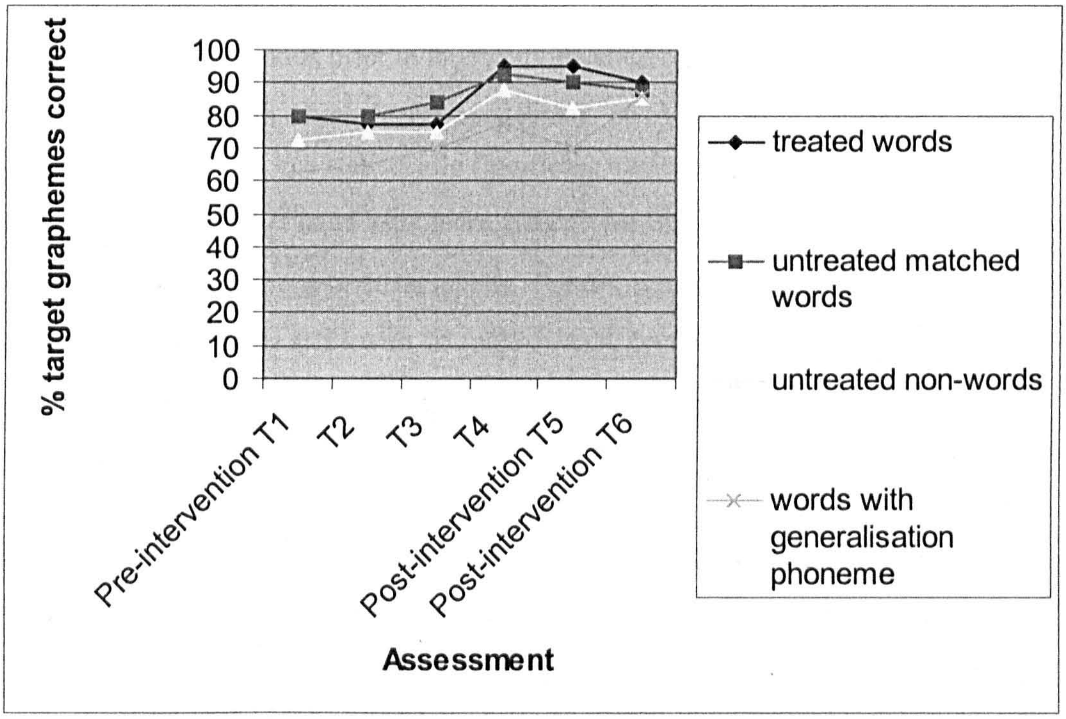
	Item	T1 assessment	T2 assessment	T3 assessment	T4 assessment	T5 assessment	T6 assessment
1	SHIP	[sɪp]	[sɪp]	[sɪp]	[sɪp]	[sɪp]	[sɪp]
2	PUSH	[pʊs]	[pʊs]	[pʊs]	[pʊs]	[pʊs]	[pʊs]
3	THIN	[θɪn]	[θɪn]	[θɪn]	[θɪn]	[θɪn]	[θɪn]
4	CHAIR	[tʃɛə]	[tʃɛə]	[tʃɛə]	[tʃɛə]	[tʃɛə]	[tʃɛə]
5	STEAL	[stil]	[stil]	[stil]	[stil]	[stil]	[stil]
6	TEST	[tɛst]	[tɛst]	[tɛst]	[tɛst]	[tɛst]	[tɛst]
7	CHILL	[tʃɪl]	[tʃɪl]	[tʃɪl]	[tʃɪl]	[tʃɪl]	[tʃɪl]
8	CHAP	[tsæp]	[tæp]	[tæp]	[tʃæp]	[tæp]	[tʃæp]
9	CATCH	[kæt]	[kæt]	[kætʃ]	[kæts]	[kæts]	[kæts]
10	STACK	[sæk]	[stæk]	[stæk]	[stæk]	[stæk]	[stæk]
11	PATH	[pæf]	[pæf]	[pæf]	[pæθ]	[pæθ]	[pæθ]
12	NEST	[nɛs]	[nɛst]	[nɛst]	[nɛst]	[nɛst]	[nɛst]
13	CHOKE	[tsəʊk]	[tʃəʊk]	[tʃəʊk]	[tʃəʊk]	[tʃəʊk]	[tʃəʊk]
14	BATH	[bæf]	[bæθ]	[bæθ]	[bæθ]	[bæθ]	[bæθ]
15	THORN	[s.θɔnz]	[s.θɔnz]	[θɔn]	[θɔn]	[θɔn]	[θɔn]
16	DEATH	[dɛf]	[dɛθ]	[dɛθ]	[dɛθ]	[dɛθ]	[dɛθ]
17	MOTH	[mɒf]	[mɒθ]	[mɒθ]	[mɒθ]	[mɒθ]	[mɒθ]
18	SHORE	[sɔ]	[sɔ]	[sɔ]	[sɔ]	[ʃɔ]	[ʃɔ]

6.1.3 Spelling

Ben's spelling was significantly more accurate than his speech at T1 (t(318) = -4.551, p<001). For example, he was unable to say [ʃ] at the outset of intervention (0% of spoken treatment stimuli correct) but was able to use it appropriately most of the time in his spelling (100% correct for written productions of treatment stimuli)[22]. After the intervention at T5 and T6 his spelling remained significantly better than his speech (t(318) = -6.041, p<001 at T5, and at T6 t(318) = -3.795, p<001. As for speech, scores for spelling focussed on the target sound, giving one point if it was correctly used in the appropriate part of the word, and giving no points if it was omitted or inappropriately used. The remainder of the word was not scored.

Figure 8.6 shows changes in Ben's written representations over the course of intervention, by stimuli group. There was a general pattern of improvement for each of the groups both treated and untreated, however for the most part the changes occurring from assessment to assessment, and when comparing T1 with T6 are not significant. There was however a significant improvement noted for the words with the generalisation sound (i.e. the voiced phonemes or other [s] cluster) when comparing T1 scores with T6 scores (t(39) = -3.365, p<.005).

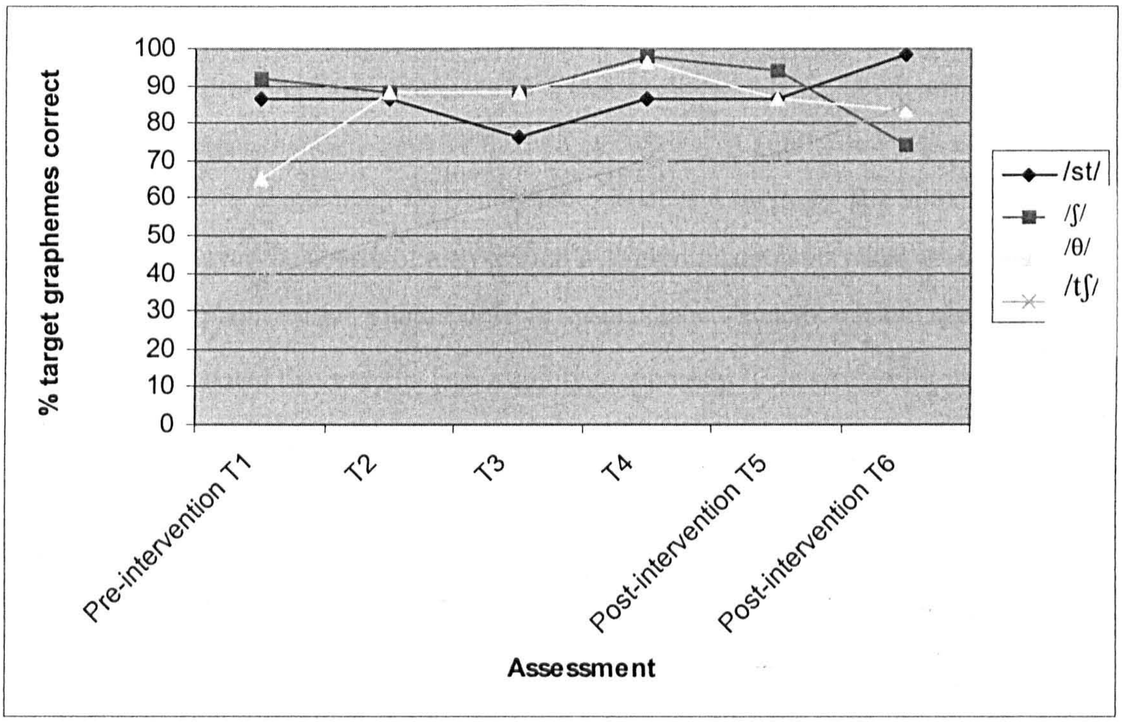
Figure 8.6
Comparison of Ben's stimuli groups over the course of intervention: spelling



[22] Although this high level of accuracy in spelling stands in strong contrast to the lower accuracy noted at initial assessment (see Table 8.4)

Figure 8.7 shows Ben's spelling progress over the course of intervention by sound category.

Figure 8.7
Comparison of Ben's sound stimuli groups over the course of intervention (spelling)



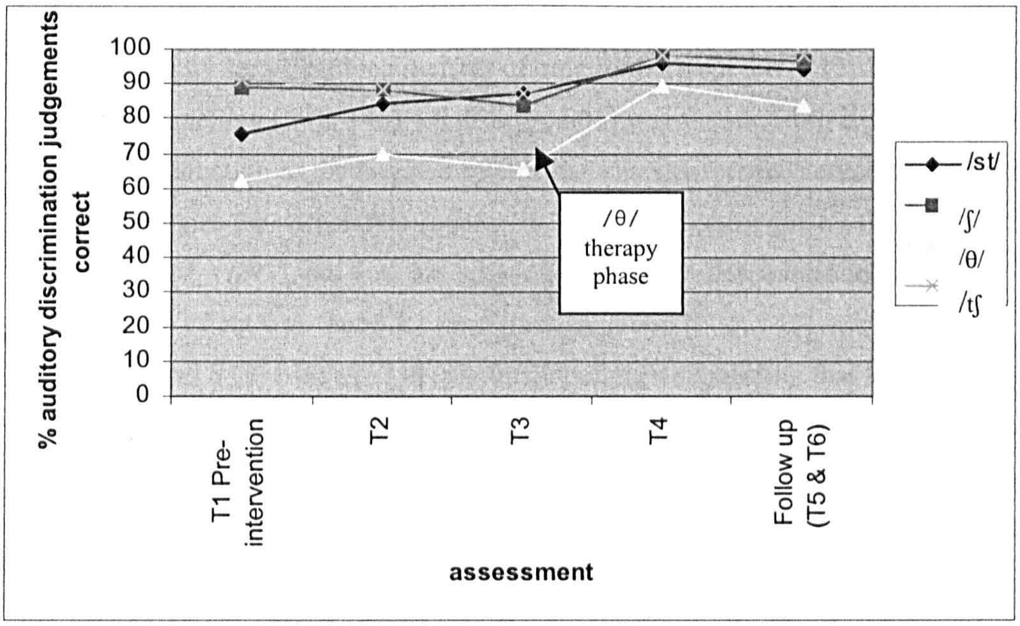
As for speech, Ben's skills prior to intervention varied considerably by sound: /st/ and /ʃ/ presented initially with a high degree of accuracy: 86.6% and 92% respectively. Both of these sounds did not change in a statistically significant way over the course of intervention. /θ/ and /tʃ/, on the other hand were more difficult for Ben and greater changes were noted for the written representations of these sounds. For /θ/, statistically significant gains were found when comparing scores at T1 with T5 ($p(59)=-4.04$, $p<.001$), and from T1 to T6 ($t(59)=-3.639$, $p=.001$). There was also a statistically significant change from T1 to T2 ($t(59) = -4.238$, $p<.001$) despite the fact that this sound had not yet been targeted. /tʃ/ made continuous improvement over the course of the programme: significant changes were noted at almost every re-assessment. Comparison of the T1 and T6 scores reveals a statistically significant improvement overall ($t(69)=-7.623$, $p<.001$). Again, this sound's improvement was not directly linked to its specific intervention phase: it was improving both before the intervention and afterwards.

Comparison of spelling (Figure 8.7) and speech (Figure 8.5) for individual sounds reveals some patterns. /st/ was similar for both speech and spelling. It was a cluster that Ben seemed to be mastering by the start of the programme. It was approaching ceiling in terms of both speech and spelling, and throughout the programme Ben was accurate in his written and spoken realisations of the sound. This did not change in any significant way for each modality. /tʃ/ was effectively modified in both speech and spelling, and again responded in fairly similar ways over the course of the programme. At T1, /tʃ/ was challenging for Ben in both speech and spelling. However, steady improvements were noted throughout the programme with these changes occurring in a way that did not seem closely linked to the specific /tʃ/ intervention phase. It seemed as if Ben's representations – both written and spoken were changing hand-in-hand for the two modalities. A similar link was noted for /θ/, which again was challenging for Ben in both speech and spelling. His initially low-scores improved over the course of intervention with significant gains made at various points. /ʃ/ is the phoneme for which a notable mismatch between speech and spelling occurred. It was noted that initially Ben's ability to represent /ʃ/ in written forms was excellent, but his ability to produce the sound was limited. This pattern was maintained over the course of intervention: /ʃ/ remained at ceiling in terms of spelling (Figure 8.7), and although some significant gains were noted in his speech production of this sound, he requires intervention to improve production of /ʃ/ beyond an accuracy level of approximately 15%. This mismatch in terms of speech and spelling for /ʃ/, and between /ʃ/ and the other sounds, is considered further in the discussion section.

6.1.4 Auditory discrimination

Ben was thought to have difficulties with the auditory discrimination of closely related words and non-words, as outlined in his speech processing profile (Fig 8.1). His auditory discrimination was assessed by presenting him with pairs of words. He was asked to say if they were the same or different. Each of these words was paired with a closely related item based on Ben's pattern of errors (e.g. SHOE v. SUE). Foils consisting of the same items repeated twice (e.g. SHOE v. SHOE) were also included for each stimuli group. The presentation order of these items was randomised. Figure 8.8. shows the changes which occurred across the intervention programme by sound set.

Figure 8.8
Comparison of Ben's auditory discrimination skills over the course of intervention by stimuli group



Comparisons of mean auditory discrimination skills at the assessment points revealed no significant changes. However, at an individual sound level, significant changes were noted for the treated /st/ words, when comparing results from T1 with those at T5 ($t(24)=-2.449$, $p<.05$) and T6 ($t(24)=-3.674$, $p<.001$). A significant decline was noted for [tʃ] after intervention had ceased, from T5 (short-term follow-up) to T6 (long-term follow-up), $t(24) = -2.449$, $p<.05$. Ben's auditory discrimination skills were relatively good for each of the sound groups at the start of the programme. Ben's auditory discrimination of /tʃ/, /ʃ/ and /st/ was not significantly different. However, he experienced difficulty with /θ/ that was significantly greater than for the other sounds ($t(25)=6.825$, $p= .001$). Although there were not clear patterns in relation to the specific sound under treatment, it was interesting to note that after the phase of therapy that focussed specifically on /θ/, Ben's discrimination of this sound from related sounds improved.

6.1.5 Summary of micro evaluation

(a) Micro evaluation focussed on the specific results of Ben's intervention by looking at changes in his processing of single words containing the sounds /st/, /ʃ/, /θ/ and /tʃ/. Intervention focused on Ben's reading, spelling, listening and spoken production. Control stimuli included words matched to the treatment set, non-words and words with a related target sound. Ben received a total of 36 hours of intervention, which was subdivided into four phases. Each phase addressed one sound and was followed by a reassessment of all items.

(b) A statistically significant main effect of time for both speech [$F(5, 145) = 11.746$, $p < .001$] and spelling [$F(5, 145) = 9.862$, $p < .001$] was found. Both Ben's written and spoken production of the targeted sounds had change over the course of the programme. The effect size for speech (eta squared = .276) was slightly greater than that for spelling (eta squared = .243), but both are large effects. For both speech and spelling, an interaction effect was found for time/stimulus group [$F(5, 145) = 5.517$, $p < .001$ (speech) and $F(5, 145) = 7.314$, $p < .001$ (spelling)] suggesting that the change occurring over time was different when comparing the treated words with the matched, untreated words. Greater change occurred for the treated items in comparison to the untreated controls.

(c) Ben's spelling performance was significantly better than his speech performance both before and after intervention.

(d) Ben seemed to be mastering /st/ by the start of the intervention. He was accurate in his written and spoken realizations of this cluster, and this did not change in any significant way for each modality.

(e) [tʃ] was effectively modified in both speech and spelling, responding in similar ways over the course of the programme. Initially /tʃ/ was challenging for Ben in both speech and spelling. However, steady improvements were noted throughout the programme. Ben's representations – both written and spoken – changed hand-in-hand for the two modalities.

(f) [θ] was challenging for Ben in both speech and spelling. His initially low-scores improved over the course of intervention with significant gains made at various points. Auditory discrimination of this target from related sounds was difficult for Ben. His performance on the auditory discrimination tasks with /θ/, was significantly poorer than his responses for the other sounds.

(g) A notable mismatch between speech and spelling occurs for /ʃ/. Ben's ability to represent /ʃ/ in written forms was excellent, but his ability to produce the sound was limited. This pattern was maintained over the course of the intervention:/ʃ/ remained near ceiling for spelling, and although some significant gains were noted in his speech production, he requires further intervention to improve production of /ʃ/ beyond an accuracy level of approximately 15%.

(h) Overall, Ben's auditory discrimination scores did not change significantly over the course of intervention.

6.1.6 Questions revisited

(a) *Was the intervention effective? If so there should be improvements in Ben's speech production of treated items beyond chance level. If the intervention was effective, does the success of the intervention vary across the four sounds targeted, and why?* Ben's intervention was effective. His mean speech scores for the treated words changed beyond chance level over the course of intervention. However, if one considers the four individual sounds, it can be seen that only two phonemes /θ/ and /tʃ/ contributed to this change over the programme. It is suggested that these phonemes were different to /st/. /st/ was approaching ceiling at the start of intervention and had little scope for significant gains, whereas /θ/ and /tʃ/ were sounds that were harder for Ben to produce and the scope for improvement was much greater. Using this same logic, /ʃ/ was the phoneme that was most challenging for Ben to produce, and thus which had greatest scope for improvement. However, the gains made for this phoneme were small. One explanation is that Ben had very limited PPK of this phoneme, and it was easier for him to make gains with sounds that he had at least some knowledge about, such as /θ/ and /tʃ/. Another explanation is that Ben's speech processing profile should have been carried out in a more phoneme-specific way. The therapy programme met the needs of the targets /θ/ and /tʃ/, but /ʃ/ may have required more tailor-made intervention. This is discussed further in the discussion section.

In terms of normal phonological development, /θ/ is a phoneme typically acquired approximately one year later (at an average CA of 6;0, Smit et al., 1990) than the phonemes /ʃ/ and /tʃ/ and the cluster /st/.

(b) *Did generalisation extend to the untreated matched control stimuli? If within-item generalisation was found, what are the patterns observed? Was generalisation greater for some of the sounds than others and how does this inform our knowledge about the relationship between the sounds?* Words matched to the target stimuli were selected as an untreated control set. Significant improvement was found when comparing T6 speech performance on this entire set of words with Ben's production of the words at T1. Despite not being targeted in intervention, these words had improved beyond chance level from T1 to T6 showing that a significant degree of generalisation had taken place. When one focused on the four individual sounds that constitute this set, it was found that only /θ/ and /tʃ/ had contributed to this change in a significant way. /θ/ made significant gains from T1 to T5, and T1 to T6. /tʃ/ improved significantly from T1 to T6. This pattern of change fits in with the change noted for the treated items: /θ/ and /tʃ/ were the phonemes that improved significantly for the treated word sets. This suggests that a significant degree of change is needed in specifically targeted items for generalisation to occur in untargeted but matched words.

(c) *Did generalisation extend to the untreated 'linked' control stimuli? If within-class generalisation was found, what are the patterns observed? Was generalisation greater for some of the sounds than others and how does this inform our knowledge about the relationship between the sounds?* Each of the targeted sounds was linked to a closely related sound, i.e. voiced counterparts for /tʃ/, /θ/ and /ʃ/, and another /s/ cluster for /st/. Overall, these words did not change significantly over the course of the programme, suggesting that within-class generalisation was limited. The number of items in these control sets was small, but patterns of generalisation emerged (see Table 8.12).

The cluster /st/ was linked to the cluster /str/. Developmentally, three part clusters are acquired later than two part clusters (McLeod et al., 1997). There was a decline in Ben's ability to accurately produce /str/ when comparing T1 and T6: no generalisation had occurred to this sound and the effects of producing an accurate /st/ seemed to be a less accurate /str/. One way of interpreting the variability in his scores for /str/ production is that he was reaching a state of developmental readiness to produce this cluster: variability is sometimes thought to precede acquisition of a sound (Grunwell, 1985).

/tʃ/ was linked to /dʒ/. No change was noted in Ben's ability to produce the /dʒ/ words when comparing T1 and T6. Given that /tʃ/ was one of the most successfully treated sounds it is interesting that generalisation did not extend to its voiced counterpart. An increase in speech production accuracy was noted for the phonemes /ʒ/ (linked with the treated /ʃ/) and /ð/ (linked to /θ/). This suggests that generalisation *can* occur from voiceless to voiced phonemes as has been suggested (Costello and Onstine, 1976), although this may not necessarily happen for all children and all phonemes. /ʒ/ is a phoneme that has low frequency in English when compared to /dʒ/ and /ð/. It does not occur word-initially. For these reasons, there was a limited number of stimuli used to assess /ʒ/, and the comparisons made between /ʒ/ may not be fair given the different frequencies and positional constraints affecting these phonemes.

(d) *Was improvement noted in Ben's repetition of non-words? If so, this would suggest that his online motor programming had been effectively altered.* Yes, the pattern of change observed for the non-words was a significant one, based on comparisons of performance at T1 and T6 ($t(39) = -3.122$, $p<.005$). Across the course of intervention, non-word scores revealed a peak of 70% accuracy after the second phase of assessment, with this falling to levels similar to those pre-intervention at T5, and then approximating 70% again at T6. The turbulent nature of changes in non-word production may reflect the fact that Ben's online motor programming was being altered in some way.

Again, /θ/ and /tʃ/ were the phonemes in the non-word sets that showed the greatest improvement over the programme. This fits in with the change noted for the treated items: /θ/ and /tʃ/ were the phonemes that improved significantly for the treated word sets. This suggests that the revision of existing motor-programmes may go hand-in-hand with changes in online motor-programming for specific sounds.

(e) *How does the intervention affect Ben's written representations of words? Are improvements beyond chance level noted for treated items and /or untreated controls, and how does this inform our knowledge of the speech-spelling link? If the intervention is effective for spelling, does the success of the intervention vary across the four sounds targeted, and why?* Ben's spelling was significantly more accurate than his speech at T1. After the intervention at T5 and T6 his spelling remained significantly better than his speech. Significant gains were made for the spelling of the untreated controls as well as the treated words, suggesting that generalisation was taking place for spelling as well as speech.

Ben's skills prior to intervention varied considerably by target sound: /st/ and /ʃ/ presented initially with a high degree of accuracy: 86.6% and 92% respectively. Both of these sounds did not change in a statistically significant way over the course of intervention. /θ/ and /tʃ/, on the other hand were more difficult for Ben and greater changes were noted for the written representations of these sounds. To some extent, this ties in with the pattern of change noted for speech: /st/ was a cluster that Ben was mastering by the start of the programme. Ben was accurate in his written and spoken realisations of the cluster, and this did not change in any significant way for each modality. /tʃ/ and /θ/ were effectively modified in both speech and spelling, and again responded in fairly similar ways over the course of the programme. It seemed as if Ben's representations – both written and spoken were changing, together for the two modalities.

/ʃ/ is the phoneme for which a notable mismatch between speech and spelling occurs. Initially Ben's ability to represent /ʃ/ in written forms was excellent, but his ability to produce the sound was limited. This pattern was maintained over the time course of the intervention: /ʃ/ remained at ceiling for spelling, and although some significant gains were noted in his speech production of this sound, he requires intervention to improve production of /ʃ/ beyond an accuracy level of approximately 15%.

(f) *Did Ben's auditory discrimination ability improve over the course of intervention? What is the pattern of change observed and how does this fit in with the changes observed for speech and spelling?* No, comparisons of mean auditory discrimination skills at the assessment points revealed no significant changes. Residual problems may remain with this level of processing that affect his speech production. A significant increase was however noted for the treated /st/ words, when comparing results from T1 with those at T5 and T6. These results suggest that highly accurate production may precede accurate discrimination skills. A significant decline was noted for /tʃ/ after intervention had ceased, from T5 to T6 (long-term follow-up), suggesting that gains made in the discrimination of this phoneme had been lost after intervention ceased. Ben experienced difficulty with /θ/ that was significantly greater than for the other phonemes. Miller and Nicely (1955) suggest that /f/ and /θ/ are amongst some of the most perceptually confusing phonemes, and this is confirmed by acoustic studies (e.g. Behrens and Blumstein, 1988). Although no significant gains were made in his perception of these phonemes overall, he did make significant gains immediately after the intervention phase that focused on /θ/. /θ/ has also been cited as one of the phonemes that was most successfully addressed for speech. The fact that similar gains did not occur for auditory discrimination, again suggests that speech changes may sometimes precede changes in auditory discrimination.

6.2 Macro evaluation

Short-term follow-up took place in March 2003, approximately one month after the completion of Ben's intervention programme at CA 9;7. Long-term follow-up took place some 7 months later at CA 10;2. The complete assessment as carried out initially in Section 2, was repeated in order to assess his progress in terms of speech, language and literacy. Assessment is grouped into four main areas: (6.2.1) standardised language assessments, (6.2.2) speech profiling carried out within a psycholinguistic framework, (6.2.3) speech analysis, and (6.2.4) child interview and parent / teacher report.

6.2.1 Standardised language assessment

Standardised tests administered at the start of the intervention, were re-administered, and results are presented in Table 8.14.

Table 8.14
Comparison of Ben's standardised speech, language and literacy assessments at CA 8;8 (pre-intervention) and CA 9;7 and 10;2 (post-intervention)

Assessment	Area tapped	PRE INTERVENTION CA 8;8 Score	PRE INTERVENTION CA 8;8 Age-equivalent	POST INTERVENTION CA 9;7 Score	POST INTERVENTION CA 9;7 Age-equivalent	POST INTERVENTION CA 10;2 Score	POST INTERVENTION CA 10;2 Age-equivalent
Receptive Language							
Test of reception of grammar (TROG, Bishop, 1989)	Receptive grammar	25th centile	7;0	75th centile	11;0	50th centile	10;0
British Picture Vocabulary Scale (BPVS, Dunn et al., 1997)	Receptive vocabulary	Std score = 78 7th centile	6;2	Std Score=99 46th centile	9;4	Std Score=99 46th centile	9;8
Receptive Subtests of CELF (Clinical Evaluation of Language Fundamentals – UK Edition, Wiig et al., 2001).	Receptive language	Std score = 9 40th centile	8;6	Std score = 9 40th centile	9;6	Std score = 9 40th centile	10;0
Expressive language							
Renfrew Word Finding Vocabulary Test (Renfrew, 1995)*	Expressive vocabulary	Z Score: -1.1	6;12	Z Score: 1.66	8;6+	Z Score: 1.66	8;6+
Clinical Evaluation of Language Fundamentals (CELF- 3), Expressive Subtests (Semel et al.,1995)	Expressive grammar	Std score = 9 40th centile	8;6	Std score = 9 40th centile	9;6	Std score = 9 40th centile	10;0
Edinburgh Articulation Test (EAT, Anthony et al., 1971)**	Articulation and naming	Std Score = 77	5;6	Std Score = 86	5;8	Std Score = 86	5;8
Literacy measures							
Schonell Reading Test (Newton and Thompson, 1982)	Reading single words	Reading Age = 7;7 years		Reading Age = 7;10 years		Reading Age = 8;1 years	
Schonell Spelling Test (Newton and Thompson, 1982)	Writing single words from dictation	Spelling Age=7;1		Spelling Age=8;0		Spelling Age=8;4	

* Renfrew Word Finding Vocabulary Test has norms up to age 8;6 which were used for Ben at all assessment points beyond this age
**EAT is designed for use with children up to the age of 6;0. Ben's scores were calculated using this upper age limit although he was older than this at each assessment

Ben's results show some change from the initial assessment. In terms of receptive language, he performed above the expected mean for his age on the TROG (Bishop, 1989) at short-term follow-up, but this elevated score is reduced at long-term follow-up to a score that is appropriate for his age. His score on the BPVS improved from initial assessment, and at both follow-ups he was found to be only a few months behind the expected norms for his age. In terms of expressive language, Ben had maintained development at the follow-up assessments. Ben's performance in literacy revealed minimal changes relative to norms for his age and taking into account the amount of time that had elapsed between assessments. His reading age had increased from 7;7 to 8;1 (6 months) over the course of the programme which lasted 20 months. His spelling age had increased from 7,1 to 8;4 years (15 months) over the 20 month period. It is interesting to note the way in which Ben's spelling age surpassed his reading over the intervention period. The intervention involved both reading and spelling. The asymmetry between the two skills is considered further in the discussion section.

6.2.2 Speech profiling in a psycholinguistic framework

Tests used to build Ben's initial speech processing profile (Figure 8.1) were carried out again in order to determine if any changes in his profile had occurred. The updated profile is presented in Figure 8.9. There were no changes noted when comparing the new profiles from long and short-term follow-up with the initial one. Ben still has auditory discrimination difficulties with both real and non-words on the input side of the profile (levels B and D), and a range of output difficulties. As noted previously his difficulties are very specific: He is able to score age appropriately on some of the commonly-used, standardised tests but finds some of the unpublished, but norm-referenced tests more challenging (see Appendix 2).

6.2.3 Speech analysis

A post-intervention PACS (Grunwell, 1985) was carried out to provide information on Ben's speech production system. This was compared with the findings from the initial assessment (section 2.3.1). Table 8.15 summarises the results.

Ben's severity indices remained high and unchanged. Ben was now producing [st] clusters more accurately. In the speech sample he was able to produce [st] correctly for 80% of possible instances. He still experiences difficulties with [str] in all word positions typically deleting [t]. [str] (SIWI) is produced variably as [sw], [s] and [sr]. Ben's accuracy of /tʃ/ had improved to approximately 60% in all word positions. /dʒ/ showed slight improvement but not beyond chance level. Ben was using [θ] and its voiced counterpart more consistently and accurately than before. His accuracy for these sounds in naming tasks and conversational speech was now estimated at 75%. [ʃ] remained challenging for Ben who was estimated to achieve approximately 7% accuracy for this phoneme in single word and spontaneous speech tasks. Again, he was not readily stimulable for this sound. [r] remains inconsistently glided to [w].

Figure 8. 9
Ben's speech processing profile at age 9;7 and 10;2 (from Stackhouse and Wells, 1997). No changes are noted when compared to his earlier profile at CA 8;8 (Fig 8.1)

√ = age appropriate performance
X = 1 s.d below the expected mean for his age
XX = 2 s.d below the expected mean for his age
XXX = 3 s.d. below the expected mean for his age

INPUT

F Is the child aware of the internal structure of phonological representations?
√ - Rhyming test (Vance et al. 1994)
√- PhAB picture alliteration subtest (Frederikson et al. 1997)

E Are the child's phonological representations accurate?
√ - Auditory lexical decision task (Constable et al., 1997)
√ - Sorting tasks

D Can the child discriminate between real words?
XXX – Real word discrimination test (Bridgeman and Snowling 1988)
√ - Aston index discrimination subtest (Newton and Thompson 1982)
X - PhAB alliteration subtest (Frederikson et al. 1997)
X - Own errors

C Does the child have language specific representations of word structures?
Not tested

B Can the child discriminate speech sounds without reference to lexical representations?
XXX – Non-word discrimination test (Bridgeman and Snowling 1988)
√ - Aston index discrimination subtest (Newton and Thompson 1982)

A Does the child have adequate auditory perception?
√ - audiometry. But has history of middle ear infections as a baby.

OUTPUT

G Can the child access accurate motor programmes?
√ – Single word naming test (Constable et al., 1997)
X – Word-finding vocabulary test (Renfrew 1995)
X – Edinburgh articulation test (Anthony et al. 1971)

H Can the child manipulate phonological units?
√ - PhAB spoonerism subtest (Frederikson et al. 1997)
√ - PAT rhyme fluency subtest (Muter et al. 1997)

I Can the child articulate real words accurately?
X –Real word repetition subtest (Constable et al., 1997)
√ - Aston index blending subtest – real Words (Newton and Thompson 1982)

J Can the child articulate speech without reference to lexical representations?
√ – Aston index blending subtest – nonwords (Newton and Thompson 1982)
X – Non-word repetition subtest (Constable et al., 1997)
X - Non-words test (Snowling)

K Does the child have adequate sound production skills?
√ - Nuffield Motor assessment; Oral examination and DDK
Finds it hard to produce [ʃ]

L Does the child reject his own erroneous forms?
Inconsistently

Table 8.15
Comparison of Ben's speech data at CA 8;8 (pre-intervention) with CA 10;2 (post-intervention)

Assessment	Pre-intervention CA 8:8		Post-intervention CA 10:2	
Severity indices	PCC 86 % PVC 99 % PPC 90.3 %		PCC 86% PVC 100% PPC 90.6%	
Phonetic inventory	Word initial position: All phonemes except [tʃ], [dʒ], [θ], [ʃ] Word medial position: All phonemes except [θ], [ʃ], [ʒ] Word final position: All phonemes except [tʃ], [θ], [ʃ], [ʒ]		Word initial position: All phonemes except [dʒ], [ʃ] Word medial position: All phonemes except [ʃ], [ʒ] Word final position: All phonemes except [ʃ], [ʒ]	
Stimulability	All phonemes except [ʃ]		All phonemes except [ʃ]	
Phonological processes analysis (% use)	Developmental processes: Cluster reduction (30%); fronting of [tʃ], [dʒ] and [ʃ] (87.5%); gliding [r] to [w] (20%)		Developmental processes: Cluster reduction (11%); fronting of [dʒ] and [ʃ] (87.5%); gliding [r] to [w] (20%)	
Single word speech sample	[tiz] for CHEESE [sæm] for JAM [fʌm] for THUMB [fɪs] for FISH [weɪk] for RAKE	[bɜfdeɪ] for BIRTHDAY [bwɪs] for BRIDGE [ɛksɪməʊ] for ESKIMO [sæl] for SHELL [Səʊk] for STROKE	[tʃiz] for CHEESE [sæm] for JAM [θʌm] for THUMB [fɪs] for FISH [weɪk] for RAKE	[bɜθdeɪ] for BIRTHDAY [bwɪdʒ] for BRIDGE [ɛksɪməʊ] for ESKIMO [sæl] for SHELL [Swəʊk] for STROKE
Connected speech sample	[aumuts] for HOW MUCH [aɪhæd.əlɪtəl] for I HAD A LITTLE [iʔgɒbwəʊkɪn] for IT GOT BROKEN [ɪ.wɜ.leɪfɔwɜk] for HE WERE LATE FOR WORK		[ə.dɪfwɪntwɜd] for A DIFFERENT WORD [ɑɪ.pæsju.əpɪktəkæt] for I PASS YOU A PICTURE OF CAT [ðəgɜlɪvdaʊnðəsrit] for THE GIRL LIVED DOWN THE STREET [ðədɒgtʃeɪstðə.kæt] for THE DOG CHASED THE CAT	

6.2.4 Child interview and parent / teacher report

The child interview, and evaluation from significant others was carried out again at CA 10;2 to provide further impressions of changes in Ben's speech.

6.2.4.1 Child interview

The same interview procedure as described in section 2.4.1 and Table 8.3 was carried out at the long-term follow-up assessment. The results of the second interview are summarised in Table 8.16 together with the results from the initial interview for comparison. Ben was comfortable with the researcher at the second interview and spoke more openly about his perceptions of his own speech. He admitted that teasing about his speech sometimes upset him. He said that he thought his speech was acceptable ('sort-of OK') and that he did not feel shy to talk in class. Ben showed some insight into communication in general, realising that literacy and languages are valuable skills for adults in the workplace. In terms of literacy it was interesting to note that despite difficulties with reading, he still enjoys reading independently at home. At this follow-up interview he commented that writing was easier for him than reading, the reverse of what he had stated at the initial interview. This reflects his scores on the literacy assessments since he achieved higher scores with spelling as opposed to reading at the second assessment, and vice versa at the first.

Table 8.16
Comparison of findings from Ben's semi-structured interviews at CA 9;2 and 10;2

Area of questioning	Main findings: CA 9;2	Main findings: CA 10;2
Ben's experience of speech and language therapy • Present (comments on phase I)	Enjoys therapy Particularly enjoys games and drawing Doesn't like the video and being recorded	Likes more than being in class: 'it gets me out of the classroom' Likes games
• Past	Can't remember	
Ben's perception and awareness of own speech	He enjoys talking but only to certain people He likes listening His speech has improved He has been misunderstood quite often	He is 'sort-of happy' with his speech Sometimes other children tease him about his speech People occasionally don't understand him, but he normally rephrases what he has said and then they do.
Ben's perceptions of communication more generally	Not everybody in the world speaks English. He knows some other languages.	Talking is very important – for getting a good job. He would like to learn some other languages.
Ben's attitudes to literacy	Reading is very important for accessing information Reading can be difficult but is easier than writing	He doesn't like reading at school. At home he likes independent reading. Reading and writing are equally important. Writing is easier than reading.

6.2.4.2 Teacher report

At the start of the intervention project, Ben's class teacher was concerned about his speech and the negative impact she considered his speech to be having on his spelling. The following year, Ben had a different teacher who seemed less concerned about his speech, believing that as his speech was always intelligible, there was no cause for concern. She was more concerned about Ben's ability to cope with the literacy and numeracy demands of the classroom, and in particular encouraged Ben to practise his reading and spelling.

Table 8.17 compares the ratings given by Ben's class teachers before and after intervention, on Bishop's CCC (1998).

Table 8.17
Comparison of Ben's ratings on the Children's Communication Checklist (Bishop, 1998) pre- and post intervention

<table>
<tr><th>CCC subscale</th><th>Example of behaviours in each subscale</th><th>Ben's score (pre-intervention CA 9:2</th><th>Ben's score (post-intervention CA 10:2</th><th>Comments*</th></tr>
<tr><td>A. Speech output: intelligibility and fluency</td><td>Intelligibility; use of immature speech sounds; rate and fluency</td><td>24</td><td>33</td><td>Scores of 27 or below require further investigation</td></tr>
<tr><td>B. Syntax</td><td>Grammatical errors, phrase length</td><td>29</td><td>31</td><td>Scores below 29 require further investigation</td></tr>
<tr><td>C. Inappropriate initiation</td><td>Ability to talk appropriately to different people; whether amount and nature of communication is appropriate for the situation</td><td>28</td><td>30</td><td rowspan="5">Scores below 132 are considered indicative of pragmatic impairment. Ben scored 148</td></tr>
<tr><td>D. Coherence</td><td>Ability to talk logically; make explicit information when needed</td><td>31</td><td>30</td></tr>
<tr><td>E. Stereotyped conversation</td><td>Use of favoured phrases and topics; over-precise manner</td><td>30</td><td>26</td></tr>
<tr><td>F. Use of conversational context</td><td>Understanding conversational rules; social appropriacy</td><td>30</td><td>30</td></tr>
<tr><td>G. Conversational Rapport</td><td>Appropriacy of initiation and response to initiation of conversation; understanding and use of facial expression, gesture and eye-contact</td><td>33</td><td>32</td></tr>
<tr><td>H. Social relationships</td><td>Friendships; interactions with children and adults</td><td>33</td><td>30</td><td>Scores of 24 or less require further investigation</td></tr>
<tr><td>I. Interests</td><td>Having very focused interests; prefers to do things alone or with others; interests in factual information</td><td>31</td><td>29</td><td>Acceptable: Scores of 28 or less require further investigation</td></tr>
</table>

* based on clinical guidelines from http://epwww.psych.ox.ac.uk/oscci/dbhtml/CCC/cccinstruct.htm

A different teacher completed the ratings pre- and post-intervention, and thus differences in the scores may reflect differences in the teachers' perspectives. Ben's speech score was initially the main area of concern revealed by the scale (Table 8.4). It can be seen that his speech is no longer regarded as requiring further investigation. Ben's speech did improve over intervention. The other areas of the profile show no cause for concern with Ben having good pragmatic skills

In order to provide further information about Ben's academic progress over the course of the intervention, SATs results were obtained from the assessments carried out at the end of Year 4 (prior to starting intervention, CA 8;9) and at the end of Year 5 (at the completion of intervention, CA 9;9). These results are shown in Table 8.18 and indicate that Ben has made some progress in his general academic work, but it is not greater than might be expected over the course of this time period.

Table 8.18
Ben's SATs results from pre-intervention (Year 4) to post-intervention (Year 5)

Area	Year 4: CA 8;9	Year 5: CA 9;9	Comment*
Reading	3C	3B	Improved 1 grade
Writing (includes spelling and handwriting)	3C	3A	Improved 2 grades
Numeracy	2A	3C	Improved 1 grade
Science	3B	3A	Improved 1 grade

* the numbers indicate the child's level of ability which moves from 1 upwards through to a target of 4 by the end of key stage 2. An A symbol indicates the child is almost ready to progress to the following level, whereas C or B suggests that they need further consolidation at that level. . Here changes are reported in 'grades' which are derived from the number of 'letter' changes occurring, i.e. 1B to 1A constitutes an improvement of 1 grade. One would expect an average child to move 2-3 grades in the course of a year.

6.2.4.3 Parents

Ben's father was very encouraging of the intervention work and believed that Ben's speech had improved. He was keen for Ben to continue coming for speech therapy, believing that there was 'further work to be done.'

6.2.5 Summary of macro evaluation

From a macro perspective, limited change was observed in Ben's speech processing skills. The speech processing profile revealed no significant change, either on the input or output side of the profile. PACS (Grunwell, 1985) revealed some changes related to the usage of particular sounds that had been targeted in intervention. The standardised language tests showed that Ben was for the most part maintaining his levels of development, and that the mismatch between himself and his age-matched peers was neither increasing nor decreasing.

The literacy tests showed that in the case of both reading and spelling the gap between Ben and his age –matched peers was widening. Greater gains had been made in his spelling than for his reading. This was supported by Ben's own viewpoint, when he suggested in the interview that reading was no longer considered easier than writing, and that the reverse was now true. Intervention involved both reading and spelling. There were also some positive comments from Ben himself, his teachers and father, but these may have reflected the fact that Ben was now emotionally more settled and more confident, or the fact that there was greater concern about his literacy and numeracy which now overshadowed the relative minor speech errors observed.

7. DISCUSSION

Ben is a child who has had intervention for his speech and language over the course of many years, but whose difficulties have not resolved. The implications of these persisting speech problems may be wide ranging in terms of the effect on his literacy achievement, and academic and social success at school. This discussion will focus on some of the issues and implications of persisting speech difficulties for the older child as exemplified by Ben. Bishop and Adam's (1990) critical age hypothesis suggests that children with speech problems that have not resolved by the age of 5;6 are at increased risk of facing literacy problems. Ben was the oldest child participating in this study. At age 8,6 at the start of the project he was well beyond the critical age and his teachers were voicing concern about the impact of his speech on his literacy. It has further been suggested that children with isolated speech difficulties have a better prognosis in terms of literacy outcomes than children with speech *and* associated language problems. Bishop and Clarkson (2003) caution that speech assessments should contextualise any difficulties against a backdrop of language skills since this is prognostically important.

Ben faced difficulties with both persisting speech problems as well as language delays, suggesting that his prognosis may be poor. The intervention that took place was focused specifically on his speech, rather than on his language more generally. The programme aimed to bring about changes in his speech processing system that would result in improved production of four target sounds. Literacy and auditory discrimination were also evaluated in the light of the close relationship between speech and these areas. It was hypothesised that changes in the speech processing system would affect speech, auditory discrimination and literacy. The intervention was successful in bringing about changes in Ben's speech production and spelling for the target sounds. Some generalisation to untreated words was also found, although the extent of this varied. The longitudinal study of children's speech processing skills carried out by Nathan et al. (in press), found that some children have core difficulties affecting their speech processing and literacy. These core difficulties – in contrast to delays - are not likely to be resolved by one intervention episode, and thus from this point of view it is not surprising that Ben's speech processing profile did not show changes from pre- to post-intervention.

What is known about the effectiveness of intervention beyond the critical age? Does it become harder to bring about change beyond this time, or is there a window of opportunity for bringing about change before another critical age at puberty? In general it is known that phonological intervention is effective (Nye, Foster, and Seaman, 1987) and that the earlier treatment is initiated, the better the outcome (Schery, 1985). In terms of intervention for reading difficulties, there is good evidence that significant improvements in reading accuracy and comprehension can be made in older children. Gillon and Dodd (1995) used spoken language training to target phonological processing and semantic / syntactic skills with 10-12 year old children evidencing severe difficulties in written and higher-level spoken language, with positive effects. For school-age children with weak language skills, language services which are integrated into the education setting by school speech and language therapists have resulted in important educational outcomes including significant gains in reading skills (Norris and Hoffman, 1993), significantly higher scores on listening and writing; improved abilities in understanding vocabulary and cognitive-linguistic concepts; increased writing skill; improved ability to follow directions with new concepts, and heightened phonemic awareness (Farber and Klein, 1999). Such studies have typically focused on children with language deficits as opposed to children specific speech deficits as well as language delays.

In Ben's case it is difficult to separate causal and co-occurring factors. For example, in the background section of this chapter it is mentioned that Ben's early speech was unintelligible, but his language was considered appropriate for his age. However, the initial assessment revealed that Ben is delayed in terms of both his receptive and expressive language. It is unclear whether his speech difficulties have resulted in literacy difficulties which in turn have reduced his opportunities for exposure to language. St Louis, Ruscello and Lundeen (1992) found that many school-age children with persisting phonological difficulties have associated language difficulties, and that the likelihood of this increases as the speech difficulties become more severe and the child gets older. Lewis (1992) suggests that speech and language difficulties may be the differing manifestations of a common core verbal deficit.

Ben's reading and spelling was delayed at both pre- and post-intervention assessment. However, it was noted that while reading was his initial strength, it improved little over the course of the intervention, whereas spelling improved considerably to become the stronger skill of the two. The intervention involved both reading and spelling, and it is difficult to account for this asymmetry in the two skills in terms of intervention. Spelling is typically thought to be a more challenging skill than reading (Bishop and Clarkson, 2003) and the fact that Ben's spelling is less delayed than his reading may be a positive indicator for future success. It should also be noted that the literacy assessments carried out with Ben at the macro level were single word reading and spelling tasks. Narrative writing and reading tasks would have provided additional insights into his ability to process and produce larger pieces of text, and as Bishop and Clarkson (2003) note, single word spelling and continuous writing can yield very different pictures.

Some researchers have attempted to address children's language in the hopes of improving not only their language but also their literacy and their speech (e.g. Hoffman, Norris and Monjure, 1990). Others (e.g. Nathan and Simpson, 2001) have addressed literacy in the hopes of improving that aspect as well as general oral language skills. To a lesser extent, researchers have focussed on speech processing and production in order to bring about change in the other domains. To some extent this may reflect misunderstandings about the term 'speech.' Speech can be conceptualised as a range of aspects specifically involved in the processing and production of speech sounds, for example as elucidated in Stackhouse and Wells' (1997) speech processing profile. In other cases, authors consider speech to represent motoric aspects of production, e.g. as exemplified in level K of Stackhouse and Wells' profile. This distinction is made clear in Bishop and Adam's critical age hypothesis, where it is clarified that long-term literacy difficulties are thought to *not* occur when children have peripheral speech difficulties such as in cleft palate. Bishop and Clarkson (2003) investigated the literacy skills of children classified as having 'speech only' difficulties, 'speech and language difficulties' and residual language deficits. They found that while the 'speech only' children performed comparably to normal controls, the 'speech and language' group of children performed below the expected mean. These authors concluded that:

> "speech difficulties, do... assume importance when they occur in the context of language impairment. Because speech problems are often the most obvious symptom of impairment in a child with communication difficulties, it sometimes happens that language is not fully assessed." (p.231).

Ben's intervention involved reading, listening and speech production for a specific set of stimuli words. Although the intervention resulted in some success in terms of his speech and spelling of some of the treatment items, generalization to some non-treated items was minimal, and no change was noted overall for his auditory discrimination skills. Possible reasons for this are considered below:

(a) *Ben's age*: There is a great deal of emphasis on the early intervention of children with speech and language difficulties (e.g. Rossetti, 1993; Pebly and Kopenhaver, 2001). By addressing these difficulties early on, one may be able to prevent the knock-on effects often described in children who have not received early support. In terms of service prioritization, it is not hard to understand the motivation behind such emphasis on early involvement. However, many children will be identified late and will not be able to benefit from this early provision. In the background section of this chapter, Ben's late referral to speech and language therapy was noted. What is the evidence for outcomes with this group? The answer depends on the nature and severity of the child's difficulties, as well as any co-occurring or factors, and the type and intensity of intervention received. Good verbal language skills can act as a protective factor making children at risk for failure more resilient (Hechtman and Weiss, 1986; Herrero and Hechtman, 1994). Furthermore, there is evidence of older children benefiting from intervention targeted at their specific and longstanding speech (e.g. Dent, 2001, Spooner, 2002) and language (e.g. Stiegler and Hoffman, 2001) problems. Ben came to the intervention with many strengths: motivation, average PIQ, good social and pragmatic skills, good levels of classroom and family support. It seems unlikely that his age alone was the sole factor in the limited success of his intervention.

(b) *Intervention was not sufficiently intensive*: There remains a great deal to be learnt about optimal intervention dosage. Case studies have demonstrated that children with specific speech difficulties require intervention that is specific and *relatively* intensive to bring about change (e.g. see Crosbie and Dodd, 2001). Intervention that has shown a transfer effect to the reading and spelling process for children with spoken-language impairment consisted of 20 hours of treatment administered in a relatively intensive manner (i.e., two one-hour individual sessions weekly with a speech and language therapist, Gillon 2000, 2002). Less intensive models of intervention or the use of LSAs may not produce the same results. Research is needed to investigate the efficiency of alternative models of service delivery, specifically for children with persisting speech deficits. For Ben, the intervention may not have been enough. The intervention may have had different results if the same number of sessions had been carried out in a more intensive manner over a shorter time scale.

(c) *Intervention was not specific enough.* Children with longstanding speech difficulties require intervention that is specifically addressed to their needs. Gillon (2002) notes that children with a history of speech-language impairment are 4–5 times more likely to have reading difficulties than children from the general population and that these difficulties tend to be persistent in nature and not readily resolved by classroom instruction. Specific and intensive interventions are required in order to help these children with both their speech and literacy skills. The importance of treating underlying deficits for written-language development is highlighted in a longitudinal study by Stothard, Snowling, Bishop, Chipchase and Kaplan (1998) which indicated that children whose spoken-language difficulties were resolved by age 5;6 at a *surface* level were found to have reading difficulties at age 15. It may be speculated that early speech-language intervention that included programmes to build underlying skills for literacy (such as phonological awareness) may have prevented the persistent academic difficulties experienced by these adolescents. Ben was identified late and not able to take advantage of such programmes.

Intervention planning in Ben's case involved careful consideration of his underlying speech processing difficulties. It was found that Ben had difficulties with both his input and output processing, and that many of these difficulties were not clear-cut ones, e.g. at each level of the profile a range of strengths and weaknesses were found. Ben performed well on some of the standardized measures that tap into a particular skill in a very general way, but had difficulties with some of the more focused tasks. The outcomes of Ben's intervention were not uniform, for some of the sounds he made good progress and generalization was noted, but for others very limited progress was made. It may be that /ʃ/ responded minimally to intervention because the intervention was not specifically tailored enough to address that particular phoneme. Ben's speech processing profile (Fig 8.1) shows in level K on the output side, that he has some difficulties with raising his tongue. These difficulties were specific to his production of /ʃ/ which Ben could produce in isolation but with considerable difficulty. Although, to some extent the intervention did involve assisting Ben with his articulation of this sound, intervention might have been more specifically addressed at this level for this sound. The peripheral nature of Ben's problems with /ʃ/ can account for the success with spelling that was noted for this phoneme in contrast to his speech production. His phonological representations were accurate for this phoneme. For /tʃ/ and /θ/, his phonological representations were not accurate. Intervention addressed itself to this need and resulted in the parallel gains for speech and spelling. The intervention was targeting /tʃ/ and /θ/, but not wholly targeting /ʃ/.

The intervention was based on speech profiling, but the profile might have been used in a more specific way. In the case of children with subtle and specific difficulties, it may be appropriate to profile at the level of individual sounds, resulting in different treatment plans for different sounds as appropriate. Ben was considered to be a child with a phonological delay, in terms of Dodd's (1995) subgroupings. However, as noted for the speech processing profile, it may have been the case that he had phonological delays for certain sounds (e.g. /tʃ/ and /θ/, and articulation difficulties for others (e.g. /ʃ/).

If one considers that the intervention was successful in terms of treating Ben's phonological delays, but that it was not as effective in addressing his articulation difficulties, then what are the implications for future intervention with Ben? Ruscello (1995) and Dagenais (1995) suggest that children like Ben with persisting difficulties, might respond to visually oriented treatment such as biofeedback techniques, when more traditional speech production and auditory techniques have failed to work. Most speech therapy – like Ben's - relies heavily on the auditory modality. For children with auditory processing difficulties, this may be inappropriate, and alternative approaches required. Ruscello acknowledges that the group of children with longstanding difficulties is likely to be a heterogenous one and that response to this type of intervention will vary. Ben did experience some auditory discrimination difficulties and these were taken into account in the intervention although they were not the only focus of intervention. It may be the case that these were not sufficiently addressed and that this is a contributing factor to the lack of successful outcomes. Examples of visual biofeedback interventions are provided by Dagenais (1995) and Dent (2001). Dent describes intervention for two older children (CA 8;6 and 10;5) who had not responded to traditional therapy, but for whom electropalatography (EPG) intervention was successful. Ben might have benefited from the use of EPG specifically for his /ʃ/ production, and in addition he may have been assisted in his production and discrimination of /θ/ and /f/, sounds which are perceptually very similar. This type of visual approach may have been another, more successful way of scaffolding around his auditory discrimination difficulties.

Some researchers have suggested that auditory perceptual difficulties underpin wide-ranging speech, language and literacy difficulties (e.g. Tallal, Miller and Fitch, 1993; Merzenich et al., 1996). Proponents of such auditory theories would suggest that children like Ben would benefit from auditory-based interventions. Certainly Ben's auditory processing skills were not addressed in any physiological way, and the results of such an assessment would have been helpful in planning for intervention. However, it should also be noted that speech production and literacy can contribute to children's development of speech processing (Stackhouse, 1992), and it seems unlikely that Ben's complex profile of deficits would be reflective of one isolated underlying problem.

Studying older children like Ben and finding effective interventions for their persisting problems is an important priority since minor speech errors may be negatively perceived by peers (Crowe Hall, 1991) and can affect self-esteem and self-confidence (Nash et al., 2001). Although Ben described teasing about his speech on occasion, his confidence had improved over the course of intervention, and his attitudes to both talking and literacy were positive. Ben has many strengths in his favour: good pragmatic skills, above average performance IQ and a positive attitude to languages and literacy. As the effects of speech on literacy and other academic areas become increasingly well-documented, children like Ben may benefit from more effective and efficient interventions that can address a combination of these areas.

CHAPTER 9: INTELLIGIBILITY

Chapter outline Page

Intelligibility has been defined as "the understandability of speech" (Yorkston, Dowden and Beukelman, 1992), "the match between the intention of the speaker and the response of the listener" (Schiavetti, 1992) and, the ability to use speech to communicate effectively in everyday situations (Osberger, 1992). It is the immediate criterion by which communicative attempts are judged, and is closely linked to communicative competence. It is an important and complex concept, but one for which there is no agreed definition or uniform measurement. The World Health Organisation's (WHO, 2002) International Classification of Functioning, Disability and Health describes the domains (1) body functions and structures, and (2) activities and participation. Impairments are defined as problems in body function or structure, and many speech and language assessments are centred at this level. The second domain includes activity, defined as an execution of a task or action by an individual, and participation in a life situation. Intelligibility falls at this level, and is a way of moving beyond impairment in the assessment process. The intervention case studies reported in Chapters 4 - 8 of this thesis focussed mainly at the impairment level both in a micro and macro way. However, it is clear that improving intelligibility is an important aim of these and other speech interventions. This chapter focuses on intelligibility as a clinical outcomes measure.

Section 1 reviews the way in which intelligibility can be measured, considering advantages and shortcomings associated with each technique, as well as the distinction between intelligibility and severity ratings. Section 2 focuses on accounts of intelligibility: what do we know about the factors that influence intelligibility? This section introduces a review of research papers that have had intelligibility as their focus. Section 3 considers intelligibility as a clinical outcomes measure, focusing more specifically on research that has used intelligibility as a way of evaluating the effectiveness of intervention. Section 4 returns to the five children outlined in the preceding chapters, explaining how changes in their intelligibility were evaluated and outlining the results for each case. The final section of the chapter, section 5 discusses the findings from the intelligibility experiment as they relate to the five children presented, as well as how these results contribute to our understanding and evaluation of intelligibility.

1. MEASURING INTELLIGIBILITY

Definitions of intelligibility vary and factors affecting intelligibility are wide-ranging and complex (Gordon-Brannan and Hodson, 2000). For these reasons, measuring intelligibility poses many challenges. Yet because intelligibility levels are frequently used in making clinical decisions, measurements need to be accurate, reliable, and valid. A starting point is to be clear about what one is attempting to measure: although intelligibility may be closely related to severity the two are different indices of speech (Kent, Miolo and Bloedel, 1994). For the purposes of this work speech intelligibility is defined as word or utterance recognition in natural communication situations (Smith and Nelson, 1985). True measures of intelligibility should thus involve listeners attempting to discern meaning from an individual's speech in a way that approximates a real-life environment. Three approaches typically used for measuring intelligibility are word identification tasks; listener-rating scales and formal assessments which make use of one or both of these methods and are normally designed to be used with a specific speech-disordered population (Kent, 1992; Gordon-Brannan and Hodson, 2000). Each of these approaches to the evaluation of intelligibility is discussed in further detail in the following sections, followed by an evaluation of the approaches.

Measures of intelligibility can also be used to index the severity of a speech disorder: 95% intelligibility would suggest that a speech disorder is mild, in contrast with 10% intelligibility where understanding is more difficult and the disorder severe. Quantitative measures of severity can be derived from connected speech or single words, and include metrics such as PCC (percentage consonants correct), PVC (percentage vowels and dipthongs correct) and PPC (percentage phonemes correct). Such metrics of severity are more widely used in intervention studies than the intelligibility measures and are discussed in further detail in the following section.

1.1 Word identification tasks

Word identification tasks require the listener, or a panel of listeners, to write down what the speaker says. An open response format is most commonly used with the listener instructed simply to write down the word or words they hear. In some cases closed-set tasks are used, where listeners are given a range of multiple-choice alternatives from which to select their responses. In this case, Kent, Weismer, Kent and Rosenbek (1989) suggest that the response set should reflect the potential speech production errors in the target population. The speech sample may consist of single words or sentences, typically pre-recorded onto an audiotape and randomised. While single word tests are easier to administer and score, connected speech intelligibility tests have more contextual validity as measures of real world validity. Scoring procedures vary but typically involve sentences being scored on the number of key words correct or by the total number of words correctly identified.

1.2 Listener rating interval scales

Listener rating interval scales require listeners to make judgements about the speaker's intelligibility using a technique such as interval scaling or direct magnitude estimation. Interval scaling requires the listener to assign a number to each recorded stimulus – most commonly 5, 7 and 9 point scales where, for example, 1=completely unintelligible, 9=completely intelligible. Direct magnitude estimation requires an estimate – typically a percentage – of parts of a sentence which are understood, e.g. 100% would indicate that a listener understood the entire sentence, whereas 50% would suggest that they understood only about half of the words. The technique is typically used with a standard, or reference stimulus, chosen as a good exemplar of "midrange" intelligibility (Weismer and Laures, 2002).

1.3 Formal tests

Some formal tests of speech intelligibility have been developed. An early example of such a test is Tikofsky's (1970) revised list for the estimation of dysarthric single word intelligibility. More recent tests, also devised for quantifying dysarthric speech include the Frenchay Test (Enderby, 1983) and Yorkston and Beukelman's (1981) Assessment of the Intelligibility of Dysarthric Speech. A computerised test, the Sentence Intelligibility Test (SIT) brings the sentence feature of Yorkston and Beukelman's (1981) test and another test, the Computerized Assessment of Intelligibility of Dysarthric Speech (CAIDS), (Yorkston, Beukelman, and Traynor, 1984) to Macintosh and Windows platforms.

For children the Children's Speech Intelligibility Measure (CSIM, Wilcox and Morris, 1999) has been devised for the assessment of single word intelligibility. Fifty words are randomly selected from given sets of words and the child repeats these onto an audiotape. Two to three listeners are then required to listen to the tape, either transcribing the words or using a multiple-choice format. Alternatively the Weiss Comprehensive Articulation Test (Weiss, 1980) includes a section for transcribing a 200-word speech sample, followed by a calculation of the percentage of words understood. The Beginners Intelligibility Test (BIT, Osberger, Robbins, Todd and Riley, 1994) was developed specifically for use with young children with hearing impairment and speech and language delays. Scoring is based on the percentage of words correctly determined.

1.4 Quantitative measures of severity: speech indices

Degree of intelligibility and severity level overlap considerably, and both are likely to be affected by many of the same factors (Yorkston and Beukelman, 1981; Gordon-Brannan and Hodson, 2000). Methods devised to quantify severity levels include percentage of consonants correct (PCC) (Shriberg and Kwiatkowski, 1982), percentage of vowels / dipthongs correct (PVC) (Shriberg and Kwiatkowski, 1982) and percentage of phonemes correct (PPC) (Dodd, 1995). These are typically calculated from a connected speech sample, but can also be obtained from single word tasks. They focus on the intended consonants, vowels or phonemes, expressing the total number correct as a percentage of the total number intended. In a study by Shriberg and Kwiatkowski (1982), experienced clinicians rated recorded samples of children's speech in terms of intelligibility, and these ratings were then linked to PCC measures. It was found that judgements of mild difficulties correlated with PCC scores of 85%; scores between 65 and 85% were considered mild-moderate, scores from 50-65% were linked with the judgment 'moderate-severe' and scores less than 50% were considered severe.

1.5 Comments on measurement techniques

The measurement techniques described are useful and have been applied on their own or in combination, in both clinical and research situations. However, the term 'intelligibility' is of little value if it is not used in a reliable and valid way. Reliable and valid measures of speech intelligibility are needed for indexing and explaining intelligibility deficits from both an articulatory and an acoustic point of view. Clearly, regardless of the purpose of any speech intelligibility measurement, the interaction of speaker, transmission system and listener must be considered foremost in making the measurement. Kent et al. (1994) carried out a review of the procedures used to assess intelligibility in children. They grouped these into those procedures which focus on the *speaker* by carrying out phonological process analysis or phonetic contrast analysis, or on the *listener* by emphasising word identification and scaling methods.

Word identification tasks have the advantages of high face validity (Samar and Metz, 1988; Schiavetti, 1992; Konst, Weersink-Braks, Rietveld and Peters, 2000). Calculating the percentage of words understood from a continuous-speech sample is thought to yield the most valid measure of intelligibility (Kent et al., 1994; Gordon-Brannan and Hodson, 2000). In addition, the metric of speech intelligibility produced - typically a percentage of words correctly heard - is readily usable by clinicians and researchers. The disadvantage is that data collection and analyses are time consuming and not always practical in clinical situations. Furthermore, the method of scoring whole words as either correct or incorrect is a fairly gross one, imparting no information about parts of words that are intelligible, and providing limited opportunities to reflect on qualitative changes that may have occurred within words as part of a pre-post design. For children with severe speech difficulties, this may be a particular problem.

An intelligibility study by Pascoe and Tuomi (2001) used a write-down paradigm to evaluate the understandability of adult, second language speakers of English with non-standard dialects, in South Africa. At the first level of analysis, whole words were scored as correct or incorrect. At a further level of analysis, the percentage of consonants and percentage of vowels / dipthongs correctly identified, were considered for each participant. Error matrices were used to determine the consonants and vowels that were accurately perceived, and those that resulted in listener confusion. An error matrix is a grid in which target phonemes (on one axis) are compared to listener's perceptions on the other. It was argued that in the case of non-standard dialects, speech and language therapists need to be able to distinguish between characteristics of the accent which do not compromise intelligibility, and those features which lead to miscommunication. The study was able to conclude by offering some intelligibility-driven suggestions for intervention targets, for South African therapists working with this specific client group.

The use of rating scales is frequently cited as a fast and easy method which does not require particular tools or training, and is practical for severely unintelligible speech when target words are not known. However, the reliability and validity of this approach are questionable (Schiavetti, 1992; Konst et al., 2000) and if it is used it should be with awareness that its validity is unproven. Formal tests are clinically useful, and have been used with a range of client groups including people with motor speech disorders, laryngeal cancer, foreign dialect, and cleft palate. Their development and use has been important in increasing awareness of intelligibility issues. However, they have been criticised due to design difficulties, e.g. Kent et al. (1989) note that the Frenchay Test (Enderby, 1983) contains word items that are highly variable with respect to syllable number and shape, making it difficult to understand the sources of variability in an intelligibility score. Also, they are designed for use with a particular speech-disordered population and when applied to other client groups may not always give meaningful results.

The phonetic indices used for severity are practical for clinicians to use: they do not require a panel of listeners and speech samples are relatively easy to obtain. However, with connected speech samples difficulties may occur with children with severe difficulties when one does not know the desired target. Flipsen (2002) suggests that these indices should be obtained from spontaneous connected speech if they are to be valid.

A further criticism of all the measurement techniques is the fact that whilst they may be able to index the intelligibility or severity of disordered speech, they are typically limited in their explanatory power, and thus in their ability to inform and monitor intervention. This important point is developed in the following section. It seems most likely that since intelligibility is not a unitary phenomenon, there is not likely to be a single adequate measure for research and clinical purposes. Kent (1992) suggests the triangulation of data, for example by using word-intelligibility tests, sentence intelligibility tests and rating scales or others as appropriate.

2. EXPLAINING INTELLIGIBILITY

Research has suggested that intelligibility measures should transcend mere indexing of severity of speech disorder and attempt to seek *explanations* for intelligibility deficits (Kent et al., 1989; Weismer and Martin, 1992). For example, dysarthric individuals may obtain identical scores on a single word intelligibility test, but qualitative perception of their speech may differ, and analysis of error matrices may reveal different strengths and weaknesses. A comprehensive model of intelligibility needs to account for these differences, which can then be used in treating speech disorders and monitoring progress. An explanatory model must relate overall intelligibility to underlying variables associated with the speech, its transmissions and perception.

As a starting point, it is helpful to conceptualise speech intelligibility scores in terms of three major variables: the characteristics of the speakers under study, the speech material used and its mode of transmission, and the characteristics of the listeners who perform the evaluations. Any work on intelligibility needs to quantify parameters in each of these areas as well as considering interaction between them (Schiavetti, 1992). Schiavetti gives the examples of (1) speech and language therapists typically holding the transmission system and listener parameters constant in order to evaluate the effect of variations in speaker parameters on speech intelligibility; (2) audiologists holding speaker characteristics and transmission variables constant to investigate the effect of a hearing impairment on speech perception, or holding speaker and listener characteristics constant and varying the transmission system when trying out different hearing aids; (3) the communication engineer holding the speaker and listener constant and varying the parameters of the transmission system (e.g. signal to noise ratio, bandwidth) to evaluate the effect of these parameters on speech intelligibility. However, Chin, Finnegan and Chung (2001) caution that in the case of hearing impaired children this distinction cannot be so clearly made: for such children deafness is an important audiological concern but questions of language acquisition, speech production and environment itself are equally important, typically involving professionals from all three areas with overlapping concerns.

A Medline search (via PubMed) was carried out using the search term intelligibility and limited to papers written in English from 1990. A total of 212 papers were found, and an overview of these is provided in Table 9.1.

Table 9.1
Results of a limited* Medline search of papers containing the keyword Intelligibility

Category of journal	Examples of journals	% total papers
Speech and Language Therapy *- focusing primarily on speech production whilst keeping transmission and listener variables constant*	Journal of Speech, Language and Hearing Research; International Journal of Communication Disorders; Folia Phoniatrica et Logopaedica	26%
Acoustics and Audiology *- focusing primarily on transmission or listener aspects typically keeping speech variables constant*	Journal of Acoustical Society of America, British Journal of Audiology, Scandinavian Audiology, Ear and Hearing	62%
Human Factors and Technology *- focusing primarily on transmission variables related to aviation, military applications and technology which could not clearly be categorised into the previous groups*	Human Factors; American Industrial Hygiene Association Journal; Aviation, Space and Environmental Medicine	0.5%
Other *- papers which could not be classified into any of the above-mentioned groups*		11.5%

* Papers written in English from 1990-2004

Each paper was categorised into groups based on Schiavetti's (1992) parameters as exemplified in (1), (2), and (3) above, and including an additional category for papers which did not clearly meet criteria for Schiavetti's groups. It can be seen that the majority of work into intelligibility has been carried out in the acoustic / audiological domain, with more limited work carried out in the speech and language therapy field. The 59 studies in the speech and language therapy category, i.e. focusing primarily on speech production whilst keeping transmission and listener variables constant, form the body of work on which much of this chapter will focus. Much of this work has focused on adults with acquired neurogenic speech deficits, e.g. Parkinson's Disease (Hammen, Yorkston and Minifie, 1994; Weismer, Jeng, Laures, Kent and Kent, 2001; Kempler and Van Lancker, 2002), Amyotrophic Lateral Sclerosis (Turner, Tjaden and Weismer, 1995; Riddell, McCauley, Mulligan and Tandan, 1995; Weismer et al., 2001), dysarthria (Weismer and Martin, 1992; Garcia and Dagenais, 1998; Whitehill and Ciocca, 2000; Hustad and Beukelman, 2001; De Bodt, Hernandez-Diaz and Van De Heyning, 2002; Hustad, Jones and Dailey, 2003; McHenry, 2003) as well as a fairly substantial amount of research into the speech and voice of laryngectomy patients (e.g. Miralles and Cervera, 1995; McColl, Fucci, Petrosino, Martin and McCaffrey, 1998; Searl, Carpenter and Banta, 2001; Prosek and Vreeland, 2001; Eksteen, Rieger, Nesbitt, Seikaly and Searl, 2003;) and hearing impaired individuals (e.g. Hargus and Gordon-Salant, 1995; Cienkowski and Speaks, 2000; Kvam and Bredal, 2000).

Studies such as these have informed our understanding of the variables which underlie intelligibility, as well as ways of measuring them, including the use of formal assessments. In terms of speaker factors we know that both segmental and supra-segmental factors influence intelligibility. *Speech sound production* seems to be the single most important factor in influencing intelligibility, but it is not likely to account for more than 50% of what makes an individual understandable (De Bodt et al., 2002). It is likely that the interaction of segmental and supra-segmental factors is an essential aspect of understanding speech intelligibility (Weismer and Martin, 1992). Segmental characteristics strongly associated with reduced intelligibility include omission of word initial phonemes, voicing errors (Miralles and Cervera, 1995), errors of consonant clusters, consonant substitutions and unidentifiable distortions. Clearly the exact errors will depend on the speech disorders of the population under study. Research with individuals with dysarthria (e.g. Weismer and Martin, 1992) has found that although intelligibility involves a number of potential phonetic dimensions, only a small number of these may be needed to predict a speaker's level of intelligibility. Kent, Kent, Rosenbek, Weismer, Martin, Sufit and Brooks (1990) investigated single word productions of individuals with amyotrophic lateral sclerosis and listeners' responses to these productions. Error profiles revealed that the intelligibility deficit does not uniformly affect all phonetic contrasts. Rather, certain contrasts seem to contribute more heavily than others to the word identification errors that define an intelligibility deficit. It seems that speakers with few segmental errors may still be unintelligible and speakers with many errors may be quite intelligible (Konst et al., 2000).

Supra-segmental features are thought to constitute about 20% of intelligibility in dysarthric speech (De Bodt et al., 2002), and include rhythm, duration of speech sounds, stress, fundamental frequency and intonation. An excessively fast or slow rate may reduce intelligibility. Studies of adults with acquired motor speech disorders show that intelligibility increases when rate is slowed to more normal levels (e.g. Yorkston and Beukelman, 1981; Pilon, McIntosh and Thaut, 1998). Atypical stress patterns may also reduce intelligibility since listeners use stress as an automatic language processing strategy and have certain expectations. Speech perception does not simply involve recording a sequence of sounds as the speech signal enters the auditory system, but attending preferentially to certain aspects of the signal. These strategies are well-practised and natural, having been shaped by the predictable structure of the incoming signal. Listening to the unusual speech signal produced by someone with a speech disorder challenges normal perception abilities, making it an effortful process. Yorkston and Beukelman (1981) provide an alternative account for the positive effect of slowed rate on intelligibility suggesting that speakers may have more time to achieve accurate articulatory placement.

In terms of *voice quality*, a harsh or hoarse voice adds noise to the signal making it harder to understand. High-pitched voices have fewer harmonics and are more susceptible to reduction in intelligibility. Voice quality may be a factor secondary to articulation and is thought to contribute no more than 30% of the intelligibility of dysarthric speech (De Bodt et al., 2002). Hyponasal speech can be harder to understand because of the loss of oral-nasal contrasts, and hypernasal speech is thought to have a slightly more serious impact on intelligibility. However, overall *nasality* is thought to be one of the least dominant contributors to intelligibility, estimated at about 5% in dysarthric speech (De Bodt et al., 2002). The De Bodt et al. (2002) study on perceptual ratings of dysarthric patients showed that the impact of articulation on intelligibility is dominant, but inclusion of other dimensions such as prosody and voice, results in a more balanced estimation of intelligibility. These authors caution that voice quality and nasality may be more important contributors for other client groups such as the hearing impaired or cleft palate populations.

In terms of the speech material used, we know that sentence intelligibility scores are higher than when single words are used (Osberger, 1992). However, a single word intelligibility estimate should not be considered as a good predictor of sentence or connected discourse intelligibility (Weismer and Martin, 1992) since speech perception is a highly complex process. In general, it seems that use of short, syntactically simple and semantically predictable sentences will increase intelligibility (Garcia and Dagenais, 1998).

Findings related to the listeners used to evaluate intelligibility are less clear. It is frequently noted that listeners who have had experience in listening to disordered speech give higher intelligibility ratings than naïve listeners without this experience (e.g. Osberger, 1992; Liss, Spitzer, Caviness, and Adler, 2002). Experienced listeners do not require personal knowledge of a speaker but rather, the ability is generalised across all individuals with the same type of disorder (Osberger, 1992), and thus experienced speech and language therapists are generally better at understanding disordered speech than non-SLT's (e.g. see Bridges, 1991). However, Fujimoto, Madison and Larrigan (1991) and Ellis and Fucci (1992) found no significant differences between the ratings given by the SLT's and naive listeners in their studies.

Higher intelligibility scores are typically obtained when listeners are able to both see and hear speakers. The average improvement in the intelligibility of a hearing impaired talker's speech between the listener-only and look-plus-listen condition has been reported to be roughly 15% (Monsen, 1983). When other visual cues (e.g., gestures, pictures, or initial letters) are used in addition to auditory signals of severely disordered dysarthric speech, intelligibility has been found to significantly increase (Hunter, Pring and Martin, 1991; Garcia and Dagenais, 1998; Hustad and Beukelman, 2001).

There have been relatively few intelligibility studies that focus on children with speech disorders. Much of the work in this area relates to children born with cleft palates (e.g. Van Lierde, De Bodt, Van Borsel, Wuyts, and Van Cauwenberge, 2002) or those with hearing impairment and cochlear implants (e.g. Chin et al., 2001; Allen, Nikolopoulos, Dyar, and O'Donoghue, 2001; Chin, Tsai and Gao, 2003), with fewer papers on autism (e.g. Koegel, Camarata, Koegel, Ben-Tall and Smith, 1998), cerebral palsy (e.g. Pennington and

McConachie, 2001) and Down syndrome (Kumin, 1994). Whitehill (2002) provides an interesting review of the literature on intelligibility measures of cleft palate speech. Although intelligibility measures are being increasingly for this population, concerns about the reliability and validity of the type of measures used were expressed as well as a reiteration of the need to use intelligibility as an explanatory factor rather than a simple index of acceptability.

Children with phonologically disordered or delayed speech have not been studied a great deal from an intelligibility point of view. Kwiatkowski and Shriberg (1992) studied the intelligibility of children with speech delays by asking caregivers to gloss a simultaneously videotaped and audiotaped sample of their child engaged in conversation with a clinician. Caregivers glossed an average of 78% of the utterances and 81% of the words correctly. A comparison of their glosses to the reference glosses suggested that they accurately understood an average of 58% of the utterances and 73% of the words. Weston and Shriberg (1992) used listeners' glosses of children's intended words to provide data for their studies of the potential influence of selected contextual and linguistic variables on word intelligibility. They found that intelligibility outcomes were associated with utterance length and fluency, word position, intelligibility of adjacent words, phonological complexity, and grammatical form. Flipsen (1995) studied parents' intelligibility ratings of their phonologically disordered children, and contrasted these with the ratings given by unfamiliar adults. Mothers understood significantly more of the words than fathers or unfamiliar adults. This is not surprising since it was noted that mothers in the study spent more time with their children than the fathers. Gordon-Brannan and Hodson (2000) carried out an investigation of pre-school children's intelligibility by comparing the scores obtained for a range of severity and intelligibility measures. The children ranged in phonological proficiency from adult-like to severely disordered. They suggested that any child above the age of four years with a speech intelligibility score of less than 66% (i.e. less than two thirds of utterances understood by unfamiliar listeners) should be considered a candidate for intervention. Their study also underlined the complexity – and importance - of measuring intelligibility. Regarding the normal development of intelligibility, it is known that greater intelligibility is associated with increased chronological age. By three years of age, a child's spontaneous speech should be at least 50% intelligible to unfamiliar adults. By four years of age, a child's spontaneous speech should be intelligible to unfamiliar adults, even though some articulation and phonological differences are likely to be present (ASHA, 1987). There remains a great deal of research to be done in determining individual factors that affect the intelligibility of children with persisting phonological difficulties.

3. INTELLIGIBILITY AS AN OUTCOMES MEASURE

Intelligibility may be regarded as the *sine qua non* of spoken language, however it has been used as an outcome measure in a very limited number of clinical efficacy and effectiveness studies in the field of speech and language therapy to date. An outcome is defined as a natural result; a consequence; or a comparison of an observation at a later point in time with an observation made earlier (Wertz and Irwin, 2001). Outcome measures provide evidence for answering questions about clinical practice and client care, and can be broadly defined as measurements which give an indication of treatment success. Robey and Schultz (1998) have described a systematic method for developing a treatment via a five-phase outcome research model that is employed by most scientific disciplines: Phase I focuses on 'discovery,' developing hypotheses about intervention to be tested in later phases; Phase II tests effectiveness; Phase III evaluates efficacy; Phase IV examines efficiency; and the final phase determines cost-effectiveness, cost-benefit, and cost-utility. Specific research designs are appropriate for each phase in the model, and the evidence about a treatment's outcome, as tested in each phase, can be rated by a level, or quality, of evidence scale.

Of the 59 SLT intelligibility papers described, a total of 15 used intelligibility as an outcomes measure, fitting into one of the five phases described by Robey and Schultz (1998). This may reflect a weakness in the search strategy as some outcomes studies will have used intelligibility as one of many secondary measures. However, different search strategies and a common consensus in the field (ASHA Special Emphasis Panel in Treatment Efficacy, 2002) suggest that this is infact the case. Because intelligibility is a difficult concept to report reliably and accurately, many researchers may prefer to use well-established standardised tests instead.

Intelligibility has been used with varying degrees of validity and reliability as an outcomes measure in several surgical and medical papers (e.g. Rieger, Wolfaardt, Jha, Seikaly, 2003; Sinha, Young, Survitz and Crockett, 2004) suggesting that for professionals not directly involved in speech and language therapy, intelligibility seems an important and, misleadingly, 'easy-to-get-at' concept. The fact that it has been used to a limited extent to evaluate SLT interventions is unfortunate since it is a key outcomes measure for much SLT work, and a factor which unites many SLT's working with disparate client groups.

Of the 15 SLT studies using intelligibility as an outcomes measure, 11 were considered to be in Robey and Schultz's (1988) Phases III-IV which are concerned with the efficacy, effectiveness and/or cost-effectiveness of specific interventions. Of these 11 papers, six focused on dysarthric clients (Yorkston, Hammen, Beukelman and Traynor, 1990; Hunter et al., 1991; Keatley and Wirz, 1994; Pilon et al., 1998; Hustad et al., 2003;

Sapir, Spielman, Ramig, Hinds, Countryman, Fox and Story, 2003), two were concerned with clients having undergone laryngectomies (Christensen and Dwyer, 1990; Max, De Bruyn and Steurs, 1997) and one focused on children with autism (Koegel et al., 1998). An interesting paper by Furia, Kowalski, Latorre, Angelis, Martins, Barros, and Ribeiro (2001) used intelligibility as an outcome measure for a package of treatment for oral cancer patients. Patients were divided into 3 groups by extent of tongue resection (total, subtotal or partial glossectomy). All patients then received speech therapy to activate articulatory adaptations, compensations, and maximization of the remaining structures for 3 to 6 months. Speech therapy was found to be effective in improving speech intelligibility, even after major resection. Different pre-therapy ability between groups was seen, with improvement of speech intelligibility in two of the groups. The improvement of speech intelligibility in the third group was not statistically significant, and this was attributed to the small and heterogeneous sample.

Flipsen (1995) notes that in working with children who have significant speech delays, the ultimate goal is to improve the child's ability to get their message across (i.e. to improve intelligibility) and from this point of view it is surprising that not more studies of this client group have included intelligibility data. While intervention studies concerned with addressing children's phonology have not used intelligibility measures (i.e. word identification tasks; listener-rating scales or formal intelligibility assessments), use has been made of speech severity indices. Dodd and Iacano (1989) included 'percentage of phonological processes' (PPP) from a spontaneous language sample as a means of evaluating gains in speech production following intervention. Holm and Dodd (1999) used PCC as one of several outcomes measures for the child in their study. Almost and Rosenbaum (1998) included a conversational measure (PCC) with the participants of their randomised control trial, showing that not only did their treatment group of children improve in terms of single word production but that they went on to show gains in their conversational speech. Although measures such as PCC are not strictly intelligibility measures, they are an important bridge between impairment-based measures and intelligibility evaluations, and can provide a concise, socially-relevant way of encapsulating the outcomes of interventions.

4. INTERVENTION CASE STUDIES: EVALUATION OF CHILDREN'S INTELLIGIBILITY

The present study aimed to use intelligibility as an outcome measurement to evaluate the clinical effectiveness of intervention carried out with five school-age children with persisting speech difficulties, presented in Chapters 4 - 8. Measures of intelligibility have seldom been used in such a way with children with phonological difficulties, and this study was therefore an exploratory, pilot approach to the area. The word-identification task or write-down paradigm was selected as the method of choice to most accurately evaluate intelligibility and intelligibility changes. Two levels of analysis were carried out. Firstly, the percentage of words correctly written down (in single words and sentences) was noted, following the procedure and analysis described by other researchers in the field (e.g. Kwiatkowski and Shriberg, 1992; Weston and Shriberg, 1992; Gordon-Brannan and Hodson, 2000). The second level of analysis involved a more fine-grained analysis of intelligibility at a segmental level to take into account qualitative changes within responses. The method used was adapted from a phonological evaluation carried out by Bryan and Howard (1992) in which they compared a child's spoken realisation for a target word, by comparing each of the consonants used by the child with the adult target, in terms of the three features of place, manner and voicing. Severity indices were also included in this analysis.

Numerous difficulties in the measurement of intelligibility have been outlined, and this study aimed to carefully describe and consider the conditions under which the measures were obtained, so that these could be refined in future studies. It has been suggested that intelligibility is not a unitary phenomenon and there is not likely to be one adequate measure for research and clinical purposes. The data gathered from the intelligibility evaluation is considered together with severity indices in this section, as well as reconsidering the micro and macro outcomes measures from previous chapters as appropriate.

4.1 Methods

This study was carried out as part of the larger intervention project using a single-case design. Thus, in this intelligibility study each child was viewed as a single case. The study aimed to compare each individual's intelligibility pre- and post-intervention by obtaining measures from a group of unfamiliar listeners in identical conditions, and relating these measures to the other outcomes measures in an attempt to explain each child's intelligibility and any intelligibility changes that were found. Speech severity indices (PCC, PVC and PPC) were also calculated for each child before and after intervention, so that severity and intelligibility could be contrasted.

4.1.1 Participants

4.1.1.1 Children

Five school-aged children (2 girls, 3 boys) between the ages of 5;6 and 9;5 participated in the study. The children and their programmes of intervention have been introduced in Chapters 4 – 8. The children attended the same mainstream school where they received individual speech and language therapy on a twice-weekly basis, with the same therapist. The children received therapy for a period of four to nine months. Therapy was based on psycholinguistic principles (see Stackhouse and Wells, 1997, 2001), following a careful analysis of each child's underlying strengths and weaknesses. The therapy activities consisted of some 'traditional' table-top therapy as well as some computer-based sessions. More details on the content of sessions and activities can be found in Chapters 4 –8 for each individual child. The children were monolingual English speakers who share a history of ongoing speech and language difficulties which have not resolved despite previous intervention. The children differed in terms of age, nature and severity of speech difficulties, concurrent problems and educational attainment. Table 9.2 presents a summary of participant characteristics.

Table 9.2
Participant characteristics

Subject	Sex	CA (across study period in years; months)	Difficulties on speech processing profile (from Stackhouse and Wells, 1997, 2001, Figure 8.1)	Sub-group (from Dodd, 1995)
Oliver	M	5;6-7;3	A, B, D, E, F, G, I, J, K	Dyspraxia
Katie	F	6;5-8;2	B, D G, H, I, J, K	Delayed
Joshua	M	6;10-8;8	E, F, G, I, J	Delayed
Rachel	F	7;1-8;10	B, D, G, I, J	Delayed
Ben	M	8;6 – 10;3	B, D, G, I, J	Delayed

Each of the children received intervention tailor-made to their specific needs, as part of a single case-study design. A range of micro and macro outcome measures was used to evaluate each individual child's progress following intervention. This chapter reports specifically on the use of intelligibility as an outcome measure.

4.1.1.2 Listeners

Naïve and unfamiliar listeners were used to judge the children's speech. First year speech and language therapy, and speech sciences students were invited to participate as listeners in the study. Students were required to:

(a) have limited experience of children with speech-disorders, i.e. to be excluded if they had worked for more than 6 months duration with a child or children with speech difficulties.

(b) have lived in Britain for the past three years and to have English as their first language.

(c) have normal speech and hearing.

This information was obtained by means of a written questionnaire. Responses from students who did not meet all three criteria were excluded from the analysis.

Thirty-three students participated in the study. Ethical approval was obtained from a university ethical committee, and students gave informed, written consent to participate anonymously in the study.

4.1.2 Materials

All the assessment and intervention sessions with the children were audio-taped using high-quality equipment (Sony MD Walkman MZ-R30 MiniDisc recorder with a Sony Condenser Microphone 5500). The child participants and their guardians had given informed consent for these recordings to be made and for these to be used anonymously for research and teaching purposes. From this body of data, a sample of speech was compiled for each of the five children pre- and post-intervention, consisting of the same 10 sentences and 20 single words spoken on two occasions, pre- and post-intervention. Intelligibility is typically found to be higher when sentences are used, although the relationship between single words and sentences might vary from child to child. Including both single words and sentences was thought to allow for a representative sample of each child's speech while also giving the opportunity to compare the relationship between the single word and sentence conditions. Sentences between 5 and 15 syllables were used. These had been obtained using repetition tasks. Oliver was not able to carry out the repetition tasks due to concentration and/or memory difficulties, and for this reason there was no repeated sentences data for him.

Single words were elicited using picture-naming tasks, and randomly selected from a large pool of items. Target productions were known for each of the utterances and semantically-linked items were not used in order to reduce contextual effects. Because of the single case design, and the fact that the children varied in terms of age and mean length of utterance, different items were selected for each child (see Appendix 6). This also reduced any learning effects within the listener group.

The inclusion of spontaneous speech posed a problem. Spontaneous, connected speech is important for valid measures of intelligibility (Kent et al., 1994). However, by definition it is unlikely that one will obtain the same spontaneous utterances on two separate occasions. However, in an attempt to include spontaneous speech, four further speech samples were included for each child. These consisted of two spontaneous sentences spoken before intervention and two (other, different) spontaneous sentences for each child post-intervention. An attempt was made to match these spontaneous items in terms of length and content.

Mini-disc audio-recordings of all the speech samples were randomised onto CD-ROMs. Because of the large number of speech samples, four CD-ROMs were created: CD 1, CD 2, CD 3 and CD 4. Each of these CDs consisted of an equal number of randomised utterances from all children both pre- and post-intervention. Each of these CDs had 10% of the utterances repeated in order to evaluate intra-judge reliability. Intra-judge reliability was defined by the Pearson's product moment correlation between test and retest scores. There was a strong positive correlation between the scores [r = .871, n = 33, p<.0005). Cronbach's α was used to compute interrater reliability. An interrater reliability (33 raters) of .6921 was obtained for the write-down procedure. Pallant (2001) suggests that ideally this value should be .7 or higher to indicate internal consistency. However, because a limited number of items comprised the scale, this slightly lower score is considered acceptable.

4.1.3 Procedure

The word-identification or 'write-down' paradigm in which words intended by the speaker are compared with words understood by the listener is consistent with definitions of intelligibility used by authors such as Gordon-Brannan and Hodson (2000). It has also been shown to be a valid, reliable measure of intelligibility and was thus chosen as the criterion measure in this study. The procedure was piloted with a group of 60 speech and language therapists to refine the procedure before being used in the study.

Each of the students was given an evaluation booklet. The cover of the booklet contained written instructions for reference, as well as a brief questionnaire designed to elicit information about the student's eligibility to participate. Sheets inside the booklet consisted of consecutively numbered blank answer blocks. Instructions were given verbally, as well as in written form on the evaluation sheets for reference. Instructions are detailed in Appendix 7.

The recordings were played to the group using a laptop computer and audio monitors (Genelec 1029A). The listeners were able to listen to each speech sample only once, having been instructed to 'write down, in normal writing, what you think the child is saying.' Four practice items were given initially to familiarise students with the task. Students attended one of four listening sessions in which they listened to speech samples from either CD 1, 2, 3 or 4. Each session took approximately 50 minutes. Eight students listened to CDs 1, 2 and 4. Nine students listened to CD 3.

4.1.4 Analysis

Two levels of analysis took place. Initially, whole words (the single words in isolation and in sentences) were the focus of the evaluation. A more fine-grained analysis then took place, looking within words at segmental features. Each of these analyses is outlined in turn.

4.1.4.1 Whole-word analysis

Single words were marked as correct where a listener's written response matched the child's target production. They were marked as incorrect where the listener's written response differed from the child's target production or where they indicated that they did not know what the child had meant. In cases where students suggested two possible 'answers' (i.e., writing <tusk or task> for TUSK), a point was awarded as long as the target item appeared. In cases where plural forms were omitted or extraneously included (i.e. writing <dogs> for DOG, or <cat> for CATS), points were awarded irrespective. The repeated sentences and spontaneous speech were marked on a word-by-word basis with points given for any correctly-matching words, again slight differences in morphology were discounted. The percentage of total words transcribed correctly in each of the 10 samples (pre- and post-intervention for each of the 5 children) was calculated. Next, the percentage of single words in isolation, and single words in sentences, transcribed correctly was calculated to yield separate single words and sentence scores for each child pre- and post-intervention. Finally, spontaneous speech scores were considered for each child.

The main objective of this study was to evaluate any changes in intelligibility that occurred within each child, from the pre-intervention assessment to the post-intervention assessment. Repeated measures t-tests were used for this purpose, with each child regarded as a single case. Results were calculated for all utterances to yield overall intelligibility scores, as well as for single words, repeated sentences and spontaneous speech.

4.1.4.2 Within-word analysis

The within-word analysis was based closely on the methods outlined by Bryan and Howard (1992, pp.362-363) for comparing a stimulus with a response. For each target item (single words and sentences), the number of consonant phonemes[23] was counted, i.e. there are three consonant targets in the single word item GASP, and 9 in the following sentence: THE MAN LIKED THE GIRL. The listeners' responses were re-evaluated by converting each grapheme into the corresponding phoneme, and then comparing it to the target consonant. Each consonant was awarded between 0 and 3 points (1 point for correct voicing, 1 point for correct manner of articulation, and 1 point for correct place of articulation). Matched consonants were awarded 3 points, and where consonants were omitted 0 points were given. For example, a listener who wrote <cusp> when Rachel produced GASP, received 8 (out of a possible 9) points. He was given 2 points for the correct place and manner features of the word initial [k], and 3 points each for the correct [s] and [p] phonemes. Another listener who

[23] Vowels were not included in this analysis because (a) they were not directly addressed in any of the children's intervention programmes, and (b) the results from PVC analyses (see Table 9.11) revealed that all children had relatively accurate vowel production. Also, vowels do not lend themselves so well to this type of feature analysis.

wrote <boo> for GASP, received 1 point (from the possible 9) for the shared manner feature of the initial stop.

Bryan and Howard (1992) outlined two versions of this scoring procedure: strict and lenient scoring. The lenient method was used for the purposes of this study. This meant that consonants in a word response did not have to occur in the same syllabic position as in the stimulus word to score for feature similarity, i.e. when comparing a CVC response such as <cap> with the CVCV stimulus CAPER, full points were awarded for the matching [k] and [p]. For sentences, this lenient procedure was again adopted, with an attempt made to match response words with stimulus words, e.g. for the stimulus THE MAN LIKED THE GIRL, the written response <like a girl> was matched, not sequentially with the first three words but logically with the last three words of the utterances. In many cases it was not possible to discern which part of a sentence had been attempted, and in such cases response and stimulus words were matched in a one-to-one, sequential way. Further details on the feature categories used, as well as examples of scoring procedures, are presented in Appendix 8. Repeated measures t-tests were used to compare mean scores for each child's pre- and post-intervention results. Results were again calculated for all utterances to yield overall intelligibility scores, as well as for single words, repeated sentences and spontaneous speech.

Severity indices (PCC, PVC and PPC) were also calculated for each child, before and after intervention and are included for comparative purposes. These indices were based on a random sampling of 50-100 utterances before and after intervention, following procedures outlined by Shriberg and Kwiatkowski (1982) and Dodd (1995).

4.2 Results

The intelligibility evaluation aimed to determination if the children's intelligibility had changed over the course of intervention. Results were analysed at two different levels: the whole-word level and within-words. Results for each of these analyses are presented in the sections that follow, starting with an overview of the results for all children and all stimuli. Results for single words (section 4.2.1), repeated sentences (section 4.2.2) and spontaneous speech (section 4.2.3) occur in the following sections. This is followed by presentation of the severity indices for each child (section 4.2.4). The results section concludes with a summary of each child's results (Section 4.2.5).

Table 9.3 presents an overview of each child's intelligibility scores from the whole-word analysis. These results represent an overall index of intelligibility based on combined scores for single words, repeated sentences and spontaneous speech. None of the children showed significant changes in their intelligibility from pre- to post-intervention when analysed at this level (Oliver: $t(24)=-1.121$, n.s; Katie: $t(31)=.19$, n.s; Joshua: $t(31)= -1.231$, n.s; Rachel: $t(31)=-1.718$, n.s; Ben: $t(31)=1.009$, n.s).

Table 9.3
Whole-word analysis: Overview of pre- and post-intervention comparison of intelligibility

Child	PRE-INTERVENTION INTELLIGIBILITY % words understood by unfamiliar listeners	POST-INTERVENTION INTELLIGIBILITY % words understood by unfamiliar listeners
Oliver	2.6	5.3
Katie	6.7	6.0
Joshua	33.4	34.1
Rachel	38.9	48.7
Ben	42.7	50.7

Table 9.4 presents an overview of each child's intelligibility scores, using the more fine-grained within-word analysis. These results are again collapsed across all conditions: single words, repeated sentences and spontaneous speech.

Table 9.4
Within-word analysis: Overview of pre- and post-intervention comparison of intelligibility

Child	PRE-INTERVENTION INTELLIGIBILITY % features matched to target by unfamiliar listeners	POST-INTERVENTION INTELLIGIBILITY % features matched to target by unfamiliar listeners
Oliver	18.2	24.9
Katie	30.8	31.1
Joshua	54.1	56.3
Rachel	57.8	74.8*
Ben	63.6	73.9*

* significant at $p<.05$ when compared to pre-intervention scores

Rachel and Ben's intelligibility increased significantly following intervention. Listeners were able to match 57.8% of Rachel's consonantal features pre-intervention, in comparison to 74.8% post-intervention ($t(31)=-3.12$, $p<.05$). Ben's pre-intervention intelligibility increased from 63.6% to 73.9% ($t(31)=-2.61$, $p<.05$). The three remaining children did not show significant changes in their intelligibility from pre- to post-intervention when results were analysed at this level. These intelligibility results are discussed in further detail in the following sections.

4.2.1. Single words

The listeners' responses to each child's production of 20 single words, before and after intervention were analysed. Mean intelligibility scores for each child using the whole-word analysis are summarised in Table 9.5. No significant difference in single word intelligibility was found for any of the children using this method (Oliver: t(19)=-1.371, n.s; Katie: t(19)= -.225, n.s; Joshua: t(19)=-1.066, n.s; Rachel: t(19)=-1.119, n.s; Ben: t(19)=-.895, n.s).

Table 9.5
Whole-word analysis: Pre- and post-intervention comparison of intelligibility for single words

Child	PRE-INTERVENTION INTELLIGIBILITY % words understood by unfamiliar listeners	POST-INTERVENTION INTELLIGIBILITY % words understood by unfamiliar listeners
Oliver	0	2
Katie	5	6
Joshua	22	28
Rachel	28	40
Ben	34	40

Results from the within-word analysis are summarised in Table 9.6. A significant increase in single word intelligibility was noted for Rachel (t(19)=-2.31, p<.05) at this level of analysis. For the other children, listeners were able to indicate a greater number of matching features at post-intervention, but these changes did not reach significance.

Table 9.6
Within-word analysis: Pre- and post-intervention comparison of intelligibility for single words

Child	PRE-INTERVENTION INTELLIGIBILITY % features matched to target by unfamiliar listeners	POST-INTERVENTION INTELLIGIBILITY % features matched to target by unfamiliar listeners
Oliver	15.7	22.2
Katie	38.2	40.2
Joshua	53.6	59.1
Rachel	56.1	74.2*
Ben	65	74.3

* significant at p<.05 when compared to pre-intervention score

4.2.2 Repeated sentences

The children were given the same sentences pre- and post-intervention in a repetition task. Oliver was not able to carry out the task due to memory and concentration difficulties, and thus there is no data from him in this section. These sentences were presented to the groups of student listeners. As for the single words, no significant changes were noted in the children's intelligibility when comparing pre- and post-intervention results at the whole-word level of analysis (Katie: t(9)=-1.807, n.s; Joshua: t(9)=1.075, n.s; Rachel: t(9)=-5.07, n.s; Ben: (t(9)=-1.186 n.s). Table 9.7 outlines the intelligibility scores before and after intervention.

Table 9.7
Whole-word analysis: Pre- and post-intervention comparison of intelligibility for repeated sentences

Child	PRE-INTERVENTION INTELLIGIBILITY % words understood by unfamiliar listeners	POST-INTERVENTION INTELLIGIBILITY % words understood by unfamiliar listeners
Oliver	n.a*	n.a*
Katie	10	5.6
Joshua	45.3	40.2
Rachel	60.2	63.8
Ben	64	73.

* Not applicable: Oliver was not able to carry out the repeated sentences task and therefore has no data for this section

Table 9.8 outlines the intelligibility scores before and after intervention using the within-word analysis. This analysis also revealed no significant changes in the children's intelligibility when comparing pre- and post-intervention results.

Table 9.8
Within-word analysis: Pre- and post-intervention comparison of intelligibility for repeated sentences

Child	PRE-INTERVENTION INTELLIGIBILITY % features matched to target by unfamiliar listeners	POST-INTERVENTION INTELLIGIBILITY % features matched to target by unfamiliar listeners
Oliver	n.a*	n.a*
Katie	18.8	15.7
Joshua	47.5	48.9
Rachel	63.1	78.4
Ben	68.7	75.5

* Not applicable: Oliver was not able to carry out the repeated sentences task and therefore has no data for this section

4.2.3 Spontaneous speech

In this study, a small sample of spontaneous utterances where the child's meaning was known, were randomly selected and contrasted with matched utterances. No significant difference was found for any of the children when comparing the two sets of results at both levels of analysis (Oliver: t(9)=-1.536, n.s; Katie: t(3)=-.758, n.s; Joshua: t(3)=-1.54, n.s; Rachel: t(3)=-.427, n.s; Ben: (t(3)=-2.662 n.s). Table 9.9 outlines the intelligibility scores for matched spontaneous speech samples before and after intervention using the whole-word analysis.

Table 9.9
Whole-word analysis: Pre- and post-intervention comparison of intelligibility for spontaneous speech

Child	PRE-INTERVENTION INTELLIGIBILITY % words understood by unfamiliar listeners	POST-INTERVENTION INTELLIGIBILITY % words understood by unfamiliar listeners
Oliver	13.4	19.3
Katie	8.1	11
Joshua	84.5	68.3
Rachel	37.8	50.1
Ben	23.7	49.6

Table 9.10 outlines the results for spontaneous speech using the within-word analysis. Again, no significant changes were noted in the children's intelligibility when comparing pre- and post-intervention results for the spontaneous utterances. The number of items used to evaluate spontaneous speech was small, and significance may have been demonstrated for at least some of the children if a greater sample of items had been used.

Table 9.10
Within-word analysis: Pre- and post-intervention comparison of intelligibility for spontaneous speech

Child	PRE-INTERVENTION INTELLIGIBILITY % features matched to target by unfamiliar listeners	POST-INTERVENTION INTELLIGIBILITY % features matched to target by unfamiliar listeners
Oliver	27.3	35.6
Katie	17	18.2
Joshua	91.1	65
Rachel	48	62.4
Ben	24	61.9

4.2.4 Severity indices

Single words were used to obtain indices of severity for each child. A set of approximately 50-100 randomly selected single words was used for each child. PCC (percentage consonants correct), PVC (percentage vowels correct) and PPC (percentage phonemes correct) were calculated for each child using guidelines in Shriberg and Kwiatkowski (1982) and Dodd (1995), before and after intervention to provide further information about any changes occurring at this macro level. The results are presented in Table 9.11.

Table 9.11
Pre- and post-intervention comparison of severity: single words

Child	PRE-INTERVENTION SEVERITY			POST-INTERVENTION SEVERITY		
	PCC % consonants correct	PVC % vowels correct	PPC % phonemes correct	PCC % consonants correct	PVC % vowels correct	PPC % phonemes correct
Oliver	23.4	68.2	39.7	27.3	84.1	48
Katie	22	74.1	41.9	49*	73.2	58.2*
Joshua	78	100	86.7	76	100	85.5
Rachel	96.1	100	97.5	94.8	100	96.7
Ben	86	99	90.3	86	100	90.6

* significant at $p<.01$ when compared to pre-intervention scores

Katie was the only child to show significant gains in her speech severity indices. She made significant gains with her overall PPC ($t(99)=-4.662$, $p<.01$), and significant gains for PCC from pre- to post-intervention ($t(99)=-6.051$, $p<.01$). Her PVC did not change significantly from pre- to post-intervention. Final consonant production formed the focus of her intervention. None of the other children revealed significant changes in their speech severity index. However, it must be noted that there were ceiling effects for some of the children, e.g. consider Rachel's PCC, PVC and PPC scores, as well as Ben and Joshua's PVC scores. The relationship between severity (as measured by PPC for single words) and intelligibility (for single words at a whole-word level) was investigated using Pearson product moment correlation co-efficient. There was a strong positive correlation between the two variables, both pre and post-intervention [pre-intervention: $r = .95$, $n = 5$, $p<.005$; post-intervention: $r = .98$, $n = 5$, $p<.005$].

4.2.5 Child summaries

4.2.5.1 Oliver

Oliver's intelligibility did not change over the course of the intervention. His single word intelligibility (Tables 9.5 and 9.6) was extremely low both before and after intervention, with the difference between the scores not reaching significance ($t(19)=-1.371$, n.s). From a qualitative perspective it was noted that while none of the listeners correctly identified

Oliver's targets for pre-intervention utterances, 25% of them were able to identify his production of some single word targets post-intervention, e.g. CAT - /k/ and /t/ were both phonemes that were addressed in therapy. Oliver was not able to carry out the repeated sentences task due to memory and concentration difficulties, and thus there was no data from him in that section. Oliver's spontaneous speech intelligibility was low and again showed no significant difference from pre- to post-intervention (t(3)=-1.536, n.s). Nevertheless a significant difference was found when comparing his intelligibility at the single word level, with the scores obtained for spontaneous speech (t(16) =-2.25, $p<.05$). This may reflect the fact that Oliver is a skilled communicator in other ways, using supra-segmental cues such as pitch variation to help convey his messages. Oliver's speech severity indices revealed severe difficulties with his consonant production, and moderate difficulties with vowel production. Significant changes in these severity indices did not occur when comparing pre- and post-intervention results.

4.2.5.2 Katie

Katie's speech severity improved over the course of intervention, while her intelligibility did not change. Her single word intelligibility (Tables 9.5 and 9.6) was very low, both before and after intervention. The difference between these pre- and post-intervention scores was not a significant one (t(19)=-.225, n.s). Katie's speech intelligibility at the sentence level similarly did not show a significant change from pre- to post-intervention (t(9)=-1.807, n.s) despite the fact that her intervention had specifically addressed connected speech. Katie also made no significant changes in her intelligibility at the spontaneous speech level when comparing pre- and post-intervention scores (t(3)=-.758, n.s). Unlike Oliver, her scores for the single word and sentence tasks were consistent, with no significant differences noted between the tasks using different stimuli. Katie was the only child to show significant gains in her speech severity indices. She made significant gains with her overall PPC (t(99)=-4.662, $p<.001$) which changed from 41.9% to 58.2%. Significant gains were also noted for her PCC scores from 22% (pre-intervention) to 49% (post-intervention), t(99)=-6.051, $p<.01$. Her PVC did not change significantly from pre- to post-intervention. Final consonant production formed the focus of her intervention.

4.2.5.3 Joshua

Joshua's intelligibility did not change significantly over the course of the intervention. At the single word level his intelligibility was greater than Oliver's and Katie's. However, the difference between his scores pre- and post-intervention was not significant (t(19)=-1.066, n.s). Joshua's intelligibility for sentences also showed no significant change from pre- to post-intervention evaluation (t(9)=1.075, n.s). For spontaneous speech, Joshua's results suggested the highest level of intelligibility for all the children. A substantial (but not significant) decrease was noted in his spontaneous intelligibility from T1 to T2 (84% pre-intervention to 68% post-intervention, in Table 9.9, $t(3)=-1.54$, n.s). This may have been due to the selection of the spontaneous utterances: the fact that they were not appropriately matched in some way, and that only two spontaneous utterances were selected for each time period. Despite the many processes still occurring in his speech and the immature quality of his speech outlined in Chapter 6, his intelligibility in spontaneous speech is good. A significant difference was noted between his single word intelligibility and his spontaneous speech intelligibility ($t(10)=-2.26$, $p<.05$). Severity indices revealed a mild-moderate level of difficulty for Joshua, with this again remaining constant over the course of the intervention.

4.2.5.4 Rachel

Rachel's intelligibility improved significantly over the course of the intervention. For single words, the whole-word analysis revealed no significant change ($t(19)=-1.119$, n.s), however the within-word analysis revealed significant improvements in intelligibility from 56% (pre-intervention) to 74% (post-intervention), $t(19)=-2.31$, $p<.05$. No significant gains were noted for the repeated sentences ($t(9)=-.507$, n.s) and spontaneous speech ($t(3)=-.427$, n.s) at either level of analysis. The difference between her single word and connected speech intelligibility was not a significant one.

Rachel's intelligibility was relatively good, and her severity indices mild, in comparison to the other children. This is not surprising given the descriptions of her speech in Chapter 7: her surface speech difficulties were more specific and less severe than the other children. Her speech severity scores (Table 9.11) were approaching ceiling.

4.2.5.5 Ben

Ben's intelligibility improved significantly over the course of the intervention, following a similar pattern to Rachel. Like Rachel, his surface speech difficulties were more specific and less severe than the other children. For single words, the whole-word analysis revealed no significant change ($t(19)=-.895$, n.s), however the within-word analysis revealed significant improvements in intelligibility from 65% (pre-intervention) to 74.3% (post-intervention, $t(31)=-2.61$, $p<.05$. No significant gains were noted for the repeated sentences ($t(9)=-1.186$ n.s) and spontaneous speech ($t(3)=-2.662$ n.s) at either level of analysis. The difference between his single word and connected speech intelligibility was not a significant one. Ben's severity indices showed a mild level of difficulty, approaching ceiling pre-intervention and not demonstrating a significant change post-intervention.

4.3 Discussion of intelligibility evaluation

Intervention was carried out with five children with persisting speech difficulties. A range of outcomes measures was used to evaluate changes which had occurred from pre- to post-intervention. The intelligibility evaluation was considered a socially relevant way of measuring overall speech outcome: if changes in the children's intelligibility could be demonstrated then the intervention might be considered as effective in a very functional way.

Two levels of analysis were carried out: one focusing on whole words, and the other looking within words at the accuracy of consonantal features. At the first level, the intelligibility evaluation did not reveal any significant changes in intelligibility for any of the children. At the more fine-grained level of analysis, significant improvements in intelligibility were found for two of the children: Rachel and Ben. Previous studies have evaluated intelligibility using only the 'whole-word' method. This study has shown that this method may be too gross to reveal differences, and that a more detailed analysis of results can show gains that would otherwise go undetected. For example, Katie made significant gains in her ability to produce final consonants (see Chapter 5). The intervention aimed to get her to produce *any* final consonant, rather than the specifically correct phoneme. One of Katie's stimuli in the intelligibility task was NOTE. In the pre-intervention sample she produces [neʊ]. Most of the listeners wrote <no> in accordance with what they heard. The post-intervention sample had Katie producing [neʊd], and most of the listeners duly wrote <node> or <nod>. The whole-word scoring system was not able to credit this improvement, but the within-word level was able to take this into account. It is clear that improvements had been made as she was now using final consonants, yet there is still likely to be a great deal of confusion for her listeners until she is able to voice final plosives appropriately and mark phonological contrasts in this position: possible next steps for intervention. It would be valuable to monitor intelligibility with children receiving ongoing intervention to determine at which point in the intervention programme intelligibility significantly improves.

The within-word feature analysis is an important contribution to intelligibility studies, yet it is not without problems. Listeners participating in the evaluation were asked to write down what they thought the children were saying. They were also instructed to guess at words or to indicate parts of words or sentence in cases where they were unsure what the entire utterance was. When listeners provided partial information (e.g. writing <c ?> or <something ending with 'b'> this was useful for the feature analysis. However, in many cases listeners entirely omitted a response providing no information about parts of the word they might have heard. In future studies, instructions should emphasise to listeners the importance of giving a response.

The fact that limited changes were noted for some of the children may be due to the method used to evaluate intelligibility. In this study listeners unfamiliar with the children were required to discern what the children were saying from audio-samples of the children's speech, many at a single word level. Many of the listeners described the task as extremely challenging, and mentioned factors such as accents, lack of visual information and context, as factors which made it so. It has been found in previous research that listeners who have had experience in listening to disordered speech give higher intelligibility ratings than naïve listeners without this experience (e.g. Osberger, 1992; Liss et al., 2002). Results from the pilot evaluation carried out with speech and language therapists could not be directly compared to the results obtained from the student listener group, but the comments from both groups suggested that the task was also very challenging for them.

Removing some of the constraints (e.g. presenting both audio and video recordings) may have meant that the children's intelligibility increased. The listeners could then have picked up on a wider range of cues which may have made the evaluation a more sensitive one. As it was, children such as Oliver and Katie who had made gains in their speech production (as evidenced by micro measures reported in Chapters 4 and 5 respectively) were not able to demonstrate these in the intelligibility task at either level of analysis.

Higher intelligibility scores are typically found when listeners are able to both see and hear speakers. The average improvement in the intelligibility of hearing impaired talker's speech between the listener-only and look-plus-listen condition has been estimated as approximately 15% (Monsen, 1983). When other visual cues (e.g., gestures, pictures, or initial letters) are used in addition to auditory signals of severely disordered dysarthric speech, intelligibility has been found to significantly increase (Hunter et al., 1991; Garcia and Dagenais, 1998; Hustad and Beukelman, 2001). Konst et al. (2000) cautioned that visual cues were absent in the experimental situation in their study. Clearly such cues provide important contextual support in real life interaction. The intelligibility assessment carried out in the present study provides information about the competence of the children's spoken language pre- and post-intervention but it does not reflect any changes in their broader competence as interactive communication partners. Further, the lack of normative data has also been cited as a methodological difficulty: we do not know how normally-developing children and adults would fare on tasks such as these.

Many of the child participants had very severe speech difficulties: Katie and Oliver were children with extremely high severity indices pre-intervention. Low levels of intelligibility were noted both before and after intervention. These levels of less than 10% indicate profoundly unintelligible speech (ASHA, 1987). As such it is unlikely that significant intelligibility gains would be made after one episode of intervention. Intervention was specific in targeting certain aspects of their speech difficulties. In Katie's case it is not surprising that overall intelligibility did not improve given the range of simplifying processes still occurring in her speech, and the fact that her speech intervention was very specifically addressed to one particular process. Similarly, Oliver received intervention for four specific consonants, but almost all consonants were potential candidates as targets and will need to be addressed in the future. Stimuli selection for the intelligibility evaluation was random, and thus the children had some opportunities to demonstrate progress for specific phonemes and phonological processes, but not as many opportunities as, for example, in their micro evaluations.

Previous findings have suggested that intelligibility is typically greater for sentences than single words (e.g. Osberger, 1992; Gordon-Brannan and Hodson, 2000). This was a general trend for the children in the present case, i.e. contrasting individual children's scores in Tables 9.5 and 9.7, shows that sentences offer greater scope for providing contextual information and grammatical cues. However, a single word intelligibility estimate should not necessarily be considered as a good predictor of sentence or connected discourse intelligibility (Weismer and Martin, 1992).

Spontaneous speech is central to the concept of intelligibility. In this evaluation single words and repeated sentences comprised the bulk of each child's speech sample. A very limited number of spontaneous items were included since they were difficult to match in terms of pre- and post-intervention production, and it is not always possible to know exactly what children with the severe speech problems were saying. Many of the children received higher intelligibility ratings for their spontaneous speech, and given that this is the most functionally relevant aspect of children's communication it is important that future studies of this kind include greater numbers of carefully matched spontaneous speech samples. For spontaneous speech, Joshua's results suggested the highest level of intelligibility for all the children. Despite the many processes still occurring in his speech and the immature quality of his speech outlined in Chapter 6, his intelligibility in spontaneous speech was good. It was noted in Chapter 6 that Joshua often uses an inappropriately loud voice. Although this is not always socially acceptable, it may have aided the listeners in the intelligibility task. This would explain Joshua's highest intelligibility score for the spontaneous items as compared to the single words or repeated sentences, as it was frequently noted when he was telling a story to the therapist that he would speak very loudly and emphatically.

Intelligibility and severity are closely related concepts affected by many common factors. The relationship between severity (as measured by PPC for single words) and intelligibility (for single words at a whole-word level) was investigated in the present study and a strong positive correlation between the two variables was found. This is consistent with the findings of Shriberg and Kwiatkowski (1982) who found similarly high correlations between the two measures. Most intervention studies that have attempted to include functional measures of changes in speech have incorporated the latter, using measures such as PCC, PVC and PPC (e.g. Almost and Rosenbaum, 1998; Holm and Dodd, 1999). These measures are relatively easy to obtain, do not require special equipment and unfamiliar listener groups, and can provide valuable information about a child's overall level of difficulty and progress. These severity results, again indicate a trend of decreasing severity with age. All the children's results are higher than their intelligibility ratings. This is not surprising given the different evaluation procedures used. The results from this study showed that such speech indices may not however always provide a full picture of a child's intelligibility. Rachel and Ben had PPC scores that suggested mild levels of severity, yet their intelligibility was only moderate, emphasising that there are additional factors at play when evaluating intelligibility. Katie showed significant gains in her PCC score from pre- to post-intervention, yet this change did not yet have an effect on her intelligibility – at least within the stringent constraints of the evaluation that took place here. This discrepancy suggests that while PPC and related measures are concerned with individual phonemes at a segmental level, intelligibility measures move beyond this, incorporating supra-segmental and other features which can have a great effect on how poorly or well a child with speech difficulties is able to make themselves understood. Rachel's intelligibility improved significantly from pre- to post-intervention, although her intelligibility was initially high to begin with. Intervention addressed one very specific aspect of her speech, yet her intelligibility improved for all words even those that did not contain the specific structures addressed in intervention. It was clear that Rachel gained a great deal of confidence as a result of the intervention and the change brought about in her speech. The initial recordings are quiet with Rachel's speech sounding generally unclear and 'mumbly.' The final set of recordings show her speaking with a strong, louder voice and it was not surprising that her speech in general was considered more intelligible. This example highlights some of the difficulties in objectively measuring and explaining intelligibility. These factors are discussed in the following section which returns to intelligibility from a more general perspective.

5. DISCUSSION

A great many unanswered questions remain about children's speech intelligibility. Firstly, the relationship between children's phonology and intelligibility remains unclear. Although it is clear that factors such as loss of phonological contrasts, homonymy and consistency affect intelligibility, it is not clear how each of these factors contributes to intelligibility, and how the factors interact with each other. In the present study, the children's intelligibility was found to increase with age, with the youngest child, Oliver having the lowest level of intelligibility, and Ben, the oldest boy, having the highest level of intelligibility.

While we know that segmental phonology alone does not contribute to intelligibility, the other factors remain hard to access and measure. Work with adult clients with dysarthria by De Bodt et al. (2002) attempted to discern variables affecting intelligibility and to weight these in terms of relative percentage contributions. The clinical importance of such information is not hard to imagine: Yorkston et al. (1992) suggested that it is precisely the sort of information that is needed in order to move towards "an intelligibility-based model of intervention." Pascoe and Tuomi (2001) were able to pinpoint specific features in the speech of their South African Black English dialect speakers which seemed to compromise intelligibility, and used these findings to suggest specific assessment and intervention approaches when working with this client group. In the case of children with phonological difficulties requiring long-term intervention, it would be helpful for clinicians to know which factors – segmental and otherwise – have the greatest effect on intelligibility, so that these could be prioritised in intervention. It may be that such factors vary from child to child, or it may be that certain factors are linked to children of different ages, phases, sub-groups or speech processing profiles. Such information would be helpful in accounting for the persisting speech difficulties which some children experience despite having normal phonetic repertoires and performing age-appropriately on standardised measures. Returning to the concept of an "intelligibility-based model of intervention," clinicians carrying out assessment procedures should be asking: what strategies, techniques or clinical approaches will make a difference to intelligibility? They should structure the intelligibility tasks in order to provide answers to these questions. Yorkston et al. (1992) give the example of varying rate, the speaker's ability to modify unintelligible utterances, the effect of semantic context – in the case of dysarthria. Research into acquired dysarthria has shown that the increased rate associated with the condition is a factor that decreases intelligibility. This fact has led to efficacy research where clinicians use various ways to reduce the speaking rate of their clients, and confirm that intelligibility improves as a result of the treatment, and treatment can be regarded as a success in terms of this important factor.

From a psycholinguistic perspective there is much to be gained from linking the concept of intelligibility into one's understanding of a child's strengths and weaknesses. Intelligibility is clearly affected by speech processing at each of the output levels, but further research is needed to consider the contributions of levels such as motor programming, motor planning and self-monitoring of one's own speech. Intelligibility can seem a large, and ungainly concept: tying it to a psycholinguistic framework may allow one to account for it more readily, and measure it more accurately. One way in which this might be done, is by linking intelligibility measures to the developmental phase model from Stackhouse and Wells (1997) (see Figure 2.3 in Chapter 2). We know that normally-developing children's intelligibility increases with age, and that the same trend is likely to be followed by children with difficulties, although at a slower pace. It may be that at the 'whole word' level of development intelligibility is low as children are concerned with meaning units in a fairly gross way. As children move through the systematic simplification phase and into the assembly phase of speech development, they may become more concerned with sound structures resulting in increased intelligibility. The dawning of the metaphonological phase may mean that they are now able to reflect on their speech in a more objective way, taking the listener's perspective into account and maximising intelligibility through careful self-monitoring. These suggestions need to be tested out more systematically in future work. One way of doing this would be to evaluate the intelligibility of young, normally developing children as they move through the stages outlined by Stackhouse and Wells. Not only would such data aid in our understanding of intelligibility development, but it would also provide a set of norms with which the intelligibility of children with speech difficulties might be compared.

From a clinical perspective, some authors (e.g. Monsen, 1981) have suggested that intelligibility indices be used for the educational placement of hearing impaired children, and monitoring of therapy progress, and others (e.g. Beukelman and Yorkston, 1979) have suggested that it is a useful index for communicating to a speaker's family and other professionals. Yorkston et al. (1992) describe measures of sentence intelligibility as critical in the clinical setting for describing whether or not a speaker is sufficiently understandable to be a functional communicator in a variety of natural settings. One might focus on sentence intelligibility, word intelligibility with and without semantic context or phoneme intelligibility. Intelligibility clearly has an important clinical role, yet it needs to be evaluated in ways that are valid and reliable, and with an understanding of the factors that affect it.

It has been suggested here that intelligibility should be routinely included in evaluations of interventions for children with phonological difficulties. The inclusion of such measures will not only enhance our theoretical understanding of intelligibility, but also add to the armoury of outcomes measures that allow us to ensure interventions are socially and functionally relevant. However, such evaluations are not without their difficulties. Numerous problems emerged in the present study. Spontaneous speech posed difficulties. For example, while wanting to keep all factors constant in pre and post measures, in natural communication situations, factors that influence speech intelligibility often occur in combination and may interact with each other in complex ways. To measure changes in spontaneous speech intelligibility in ways that are reliable and valid, may mean to lose what lies at the heart of intelligibility: spontaneity and 'real life' communication. When children with very severe difficulties are included in intelligibility evaluations with unfamiliar listeners, the task may become extremely challenging. In such cases, using visual information may allow for a task at a more appropriate level of difficulty in which subtle changes in children's communication can be more readily discerned.

The speech of developing children may not lend itself to the type of intelligibility work which has been carried out with the adult dysarthric population, i.e. there may be too many factors at play, and more differences than similarities in a disparate group: we may never be able to assign percentage to factors contributing to intelligibility in the same way that has been done for some of the adult client groups. However, this should not deter researchers and clinicians from investigating intelligibility more fully for this group since it is widely agreed that:

> "Intelligible speech is the long term goal for most intervention approaches for children with speech disorders." (Dodd and Bradford, 2000, p.191)

The evaluation presented in this chapter attempted to devise a method for the reliable and valid measurement of intelligibility. The procedure was used successfully to this end, although suggestions have been made for future modifications. Intelligibility needs to be routinely evaluated both in intervention studies and in the clinic. Evaluations such as the one carried out here contribute to a body of knowledge about intelligibility and the factors that constitute it. Refinement of procedures for measurement of intelligibility will also inform our knowledge of these factors and ensure that our clinical outcomes are ultimately more valid, reliable and meaningful.

CHAPTER 10:
DISCUSSION OF THEORETICAL ISSUES

Chapter outline Page

This chapter returns to the issues introduced in Chapter 2 regarding the normal development and organisation of speech and language, as well as theories about speech and language disorder. The chapter aims to compare and contrast the cases presented in the preceding chapters, drawing together the theoretical contributions made. The starting point of the chapter (Section 1) is an evaluation of Stackhouse and Wells' (1997, 2001) speech processing model in terms of how adequately this model can account for the five children presented, and their responses to intervention. Evidence from generalisation patterns is considered, and used to reflect on the nature of the specific processing levels hypothesised by Stackhouse and Wells (1997, 2001), as well as modularity more generally. Developmental phase models are re-considered in section 2, in the light of the children investigated in this project and specifically focusing on Stackhouse and Wells' (1997) developmental phase model. Theories about speech and language disorder are considered in section 3, with particular consideration given to motor programming and the controversial diagnostic category of dyspraxia; mapping theories, auditory theories and sub-grouping / profiling approaches. The chapter concludes with a summary of the theoretical contributions made (section 4).

1. STACKHOUSE AND WELLS' SPEECH PROCESSING MODEL

This section aims to evaluate Stackhouse and Wells' (1997, 2001) speech processing model as a theoretical account of what happens when children process speech and language, based on the five cases presented. A further evaluation of the model as a clinical tool is presented in Chapter 11. In intervention studies, generalisation of treatment effects is one way in which the organisation of the speech and language processing system can be investigated. Patterns of generalisation for the five child participants are considered in section 1.1.

1.1. Generalisation of treatment effects

1.1.1 Across-item generalisation

Table 10.1 summarises across- item generalisation patterns noted for each child. Across-item generalisation can offer insights into the organisation of linguistic units within speech processing modules. It can be seen that across-item generalisation was a widespread phenomenon for many of the children. It was almost always found to extend to the matched sets of words devised for each child on the basis of spoken language frequency, developmental norms for acquisition age, and phonetic structure. The fact that generalisation extended to such items is not surprising given what is known about the way in which lexical items are stored. Current theories suggest that lexical representations are most likely organised into a distributed network of interconnected micro-features that are shared by many different words (e.g. Coltheart and Byng, 1989; Patterson, 1990; Lieberman, 2000). All the children, had a control set of untreated words which was matched for age of acquisition and language frequency, as well as by phonological structure (usually with onset phonemes matched) to the treatment stimuli. All the children, except Ben, showed significant generalisation to these wordlists providing some evidence for close links between words matched in this way.

Table 10.1
Summary of across-item generalisation for each child

Child	Across-item generalisation observed	
	Yes	No
Oliver	▪ From treated to untreated matched words	▪ From treated to untreated, new words ▪ From treated (phoneme in word initial position) to untreated word with phonemes in word final position
Katie	▪ From treated to untreated matched words	
Joshua	▪ From treated (novel) words to untreated (matched) non-words ▪ From treated (novel) words to untreated familiar words	
Rachel	▪ From treated to untreated matched words ▪ From treated (phoneme in word final position) to untreated word with phonemes in word initial position ▪ From treated to untreated non-words ▪ From treated s-cluster words to words with other untreated s-clusters ▪ From treated s-clusters words to words with untreated singleton /s/ ▪ From treated s-cluster words to words with other untreated fricatives	
Ben		From treated words to ▪ Untreated matched words ▪ Untreated matched words with related phonemes (i.e. voicing cognates or related cluster) ▪ Untreated non-words

Findings were conflicting about generalisation from phonemes in one word position to another: this was something that did not occur for Oliver (for a specific set of phonemes, from word initial to word final position) but that did occur for Rachel (for a different set of phonemes, from word final to word initial position). These children were different overall in the severity of their difficulties and their responses to generalisation. Rachel had relatively minor difficulties with her speech processing, and generalisation was widespread for her after a relatively short period of intervention (10 hours). Oliver on the other hand, had widespread difficulties of a severe nature. Intervention dosage was 28 hours in total and his generalisation less widespread. It may be that generalisation occurs more readily from word final to word initial position (as for Rachel), rather than from word initial to word final position (as for Oliver), but this has not been found in previous studies and given the wide differences between the two cases, as well as the fact that different phonemes are involved, such conclusions are probably not justified.

There is some evidence that lexical representations are stored in phonological neighbourhoods organized by phoneme similarity in the onset-nucleus *or* rhyme positions of overlap (Storkel, 2002). Oliver's generalisation patterns fit with this: according to 'neighbourhood' theory, working on word-initial consonants may lead to generalisation to other words with the same onset, or linked words with the same rime, e.g. working on word-initial /k/ in items such as CAT will result in generalisation to untreated words such as CAP and KEY which share the onset, and words such as HAT and BAT which share the rime. Words such as MAKE and PICK with the target /k/ in final position are not part of the neighbourhood and one would thus not expect to see effects of generalisation extend to these words. Katie's intervention targeted final consonants, with untreated controls matched in terms of rime. Generalisation extended to these items, again supporting the theory.

Rachel's widespread generalisation does not accord so well with the model, but it may be that her system was fundamentally different to Oliver's with more well developed representations already existing between lexical items. Furthermore, the stimuli items addressed in intervention were of low spoken language frequency and more unusual phonological structure (e.g. WASP, CUSP). According to Storkel (2002) these items would be located in sparse phonological neighbourhoods with more limited links to other lexical items. The fact that widespread generalisation did extend to the rest of the system after addressing these items suggests that (a) the organisation of these sparse neighbourhoods may be fundamentally different to the organisation of dense neighbourhoods, and (b) that addressing words from sparse neighbourhoods may offer scope for greater generalisation because the activation is more concentrated through a smaller network of items.

Generalisation to new or non-words was noted for Rachel and Joshua. Non-word (or new word) processing involves a different processing path than that used for real words, and thus understanding this type of across-item generalisation involves consideration of different processing paths rather than just focusing on the items within one level. Rachel, for example, repeated non-words phonetically matched to the treatment stimuli as part of her assessment (see Table 7.12). Stackhouse and Wells (1997, 2001) conceptualise such a task as involving the mapping of phonological information on the input side onto the online motor programming system. The fact that Rachel was able to do this with significantly increased accuracy following intervention informs us that her input skills, mapping skills and online motor programming were sufficiently modified to be able to carry out the task with more success. The earlier models proposed by Hewlett (1990) and Dodd and McCormack (1995) offer similar accounts of the changes observed. Dodd and McCormack (1995) conceptualise a direct line from perceptual analysis to the phonological plan, which omits lexical knowledge as well as the application of any realisation rules. From their perspective, the fact that Rachel improved significantly in her non-word repetition would suggest that intervention must have addressed auditory perception, phonological planning or motor execution (or a combination of these areas). Given that no difficulties in motor execution were noted for Rachel, it seems likely that the dual focus of intervention on auditory perception and phonological planning was effective in targeting these areas.

In Joshua's case new words were central to the intervention: He was introduced to new words in order to alter his online motor programming, create new representations of these words and ultimately to 'shake up' his inaccurate motor programmes for words with related phonemes. To some extent, this strategy was successful: Joshua was able to improve his speech production of the stimuli words, and generalisation was noted for matched non-words as well as real and familiar words. This generalisation suggests too that his online motor programming accuracy had improved (at least for the cluster phonemes in question) and that his stored motor programmes had been 'shaken up' by the introduction of more accurate items. This is good evidence for having two separate motor programming centres (online motor programming and stored representations), and for the two-way flow of information between the two levels. Hewlett (1990) explicitly incorporated 'time free' and 'real time' information flow in his model of speech processing, indicating that the 'motor programmer' serves to both create new programmes for immediate production and to devise output representations that can be stored for future use. Similarly, 'stored routines' are an important part of Dodd and McCormack's model with these being closely linked to online phonological planning. According to this model, Joshua's intervention involved emphasis on phonological planning which then had an influence on the pre-existing stored routines.

Nippold's (1992) notion of thresholds for storage and retrieval was a useful one that helped to account for some of the children's responses to intervention. For example, Joshua and Ben both made some gains in their initial phases of intervention but these fluctuated a great deal and ultimately significant gains were not made. Joshua did not remember the meaning of many of his new words following intervention. It may be that the amount and/or quality of information needed across children to reach a 'normal' threshold varies widely. The notion of varying thresholds from child to child, and from lexical item to lexical item, may go someway in accounting for individual responses to intervention. Thresholds may also be a more specific way of conceptualising memory: some children remember new words with only a few exposures to the item; for others remembering words is more of a challenge requiring more exposure. Short-term memory has become increasingly implicated in accounts of disordered speech and language development (Gathercole and Baddeley, 1990; Gupta and MacWhinney, 1997). References to the clarity or 'fuzziness' of lexical representations (e.g. see Constable, 1997; Stackhouse and Wells, 1997, 2001; Chiat, 2000) may also link in with the concept of thresholds: children with fuzzy representations have reached the threshold for storage of an item, but this is the minimum requirement for storage and ongoing input is needed to hone the clarity of the representation.

In Oliver's case generalisation did not extend to his production of non-words. Significant improvement in his naming of treated words was noted, but not for his repetition of untreated non-words. The difference in the processing routes required for these two tasks is that the former involves access of stored motor programmes and the latter involves online motor programming. Oliver was able to update existing, but inaccurate motor programmes as a result of the intervention, but the processing of new words in real time had not been affected. What did Oliver do in order to update his existing motor programmes? Accounts of this process are given by Hewlett (1990) and Stackhouse and Wells (1997, 2001). These authors suggest that the child must first become aware of the mismatch between the stored motor programme and the phonological representation. The child then needs to revisit the motor programming process creating a modified programme to become the new stored motor programme. Such a revision requires that motor programming is able to create new programmes in an efficient way. But, what exactly does motor programming entail? Stackhouse and Wells (1997, p.163) describe this component of speech production as follows:

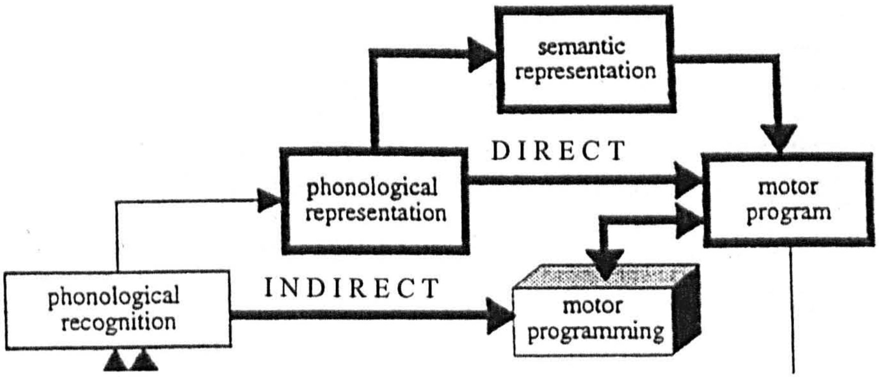
> "Motor programming can be thought of as comprising a store from which phonological units are selected, and a process of assembling these units in new combinations. An analogy would be a child's box of letters, from which you can make a selection, then sequence them in new combinations to create new words. However, in the case of speech the phonological units are unlikely to be segment-sized, particularly for the younger child...the store can be thought of as containing the set of the possible onsets and of the possible rhymes of English."

Similarly, Levelt's (1989) 'blueprint of the speaker' includes phonological encoding, a process of selecting phonological units in a left to right fashion. Levelt acknowledges that the syllable first appears at this level, before phoneme specific programming is involved. From a developmental perspective, Maassen (2002) revised Levelt's (1989) model to include 'optional' phonological coding that may not be available to young children. Hewlett (1990) refers to 'motor processing' modules, while Chiat (2000) and Hulme and Snowling (1992) refer to articulatory planning. Dodd and McCormack (1995) and Ozanne (1995) describe a phonetic planning level, following the generation of the phonological plan. This level, akin to Stackhouse and Wells' motor planning level and Hewlett's (1990) motor processing modules, is thought to involve three sub-processes. These include conversion of the phonological plan into a motor-speech programme, assembly of the phonetic units into appropriate sequences, and concluding with the implementation of the programme. A distinct module is then posited for motor execution itself.

Oliver was not able to devise motor programmes for unfamiliar words containing the phonemes that had been addressed in intervention, with any significant degree of accuracy.

He was able to produce the phonemes in question in isolation and in the familiar words worked on in therapy, as well as in matched, untreated control words. Generalisation from the treated to untreated matched items has been accounted for by the way in which these words are stored in close proximity or with many links in the motor programme store. The fact that Oliver could not produce the unfamiliar words suggests that he did not have access to an efficient motor programming device. He did not have the segmental level skills, and at the syllabic level he only had access to a very restricted range of syllables and sequences. Oliver's motor programming is a major difficulty for him, particularly revealing itself in non-word repetition tasks to which he could only respond with a very gross mapping of the input representations onto his restricted inventory of syllables. However, the question remains that if Oliver had such difficulties with his motor programming then how was he able to accurately revise his existing representations of words, achieving this with a fair degree of success? Intervention could be conceived of as training motor programming to more accurately produce words with certain phonological frames (at a syllabic level) or words with particular phonemes, ideally at onset since the direction of the 'device' is thought to be from left to right (Harley, 2001). However, if this is the case then Oliver should have been able to cope better with the non-words which were closely matched to the treatment items in terms of phonological structure. An alternative suggestion is that Oliver's motor programming is so limited that a different process takes place avoiding motor programming altogether: He creates whole word mappings of phonological forms onto motor programmes using the direct link between the two stores, as shown in Figure 10.1.

Figure 10.1.
Direct and indirect mapping of motor programmes



It has been suggested that children's phonological representations are sparse, enabling them to recognise the same word produced by a variety of speakers in a variety of different ways

(Stackhouse and Wells, 1997, 2001). If this sparse knowledge is the blueprint for Oliver's motor programmes then it is not surprising that his speech is inconsistent and often unintelligible. Intervention aimed at improving Oliver's phonological representations and this was a successful strategy in updating his motor programmes on a word-by-word basis, i.e. accounting for the minimal generalisation observed. Oliver had relatively good semantic knowledge, and if one considers the close links between phonological representations, semantic representations and motor programmes (Figure 10.1), then it is another argument for the way in which Oliver was able to improve his production of the treated (and untreated) words by relying on top-down processing strengths and avoiding his problematic motor programming. When faced with non-words there was no top-down knowledge to access and he was forced to either map directly from a freshly created and fuzzy phonological representation directly to a motor programme or to attempt to use his motor programming skills which are also deficient.

Whiteside and Varley (1998) conceptualise a dual route for speech encoding in adults. It is similar to what is described above, in that the direct route involves retrieval of a stored form and the indirect route involves assembly of speech from sub-syllabic units. These authors noted that the direct route is used for high-frequency words and forms a direct connection between semantic knowledge and whole-word motor programmes. They conceptualise apraxia of speech (AOS) in adults as an impairment of the direct route for speech encoding, so that adults with AOS have to use the indirect route resulting in slower speech and many errors. Maassen (2002) considers this notion in the light of developmental data and suggests that the direct route might apply early in development with children not yet having access to phonological encoding or motor programming. This fits in with Stackhouse and Wells' developmental phase model of an early whole-word phonology phase (Figure 2.4). Taken further, children with abnormal speech development may remain stuck at this whole-word phase with limited access to phonological encoding, which would explain the problems of non-word repetition frequently cited in studies of such children (e.g. Botting and Conti-Ramsden, 2001), as well as Oliver's difficulties.

Katie was another child who experienced major difficulties with her motor programming. Velleman's (2002) 'phonotactic therapy' was an important influence on Katie's intervention planning. This therapy focuses on building up accurate phonotactic frames, a fairly basic motor programming task, before focusing on 'filling up' the phoneme slots within the frames with accurate realisations. Katie's speech output initially showed characteristics of this whole word phase: she relied heavily on CV syllable structure and benefited from expanding her limited syllable structures to include CVC units, thereby enabling her to make a much greater range of lexical contrasts. Unfortunately, non-words were not included as untreated controls in Katie's evaluations so that it is difficult to know if her online motor programming was altered. Anecdotally, there was some evidence to support development of online motor-programming: Katie was observed in the classroom producing new vocabulary items with some appropriate final segments. Katie's speech improvements did not show up at the macro level, i.e. no significant change was noted on level G of the speech processing profile (Figure 5.1) as measured by assessments such as the Bus Story (Renfew, 1969) or on level J by the Constable non-word repetition subtest (1993). It seems that although intervention was specific and change resulted in a particular aspect of her motor-programming (i.e. she now had a CVC phonotactic frame when needed), it may not have been sufficient to affect her spontaneous speech (i.e. she still has a limited phonetic repertoire and many simplifying patterns). Dodd and McCormack's (1995) speech processing model considers that realisation rules act upon phonological plans prior to phonetic assembly. This is useful since it allows one to explain that Katie made gains in terms of her phonetic assembly and motor programming, but that immature realisation rules still act prior to these levels to simplify her speech. In Chapter 5 it was shown that Katie's difficulties were widespread throughout her speech processing system, and it has been acknowledged that while intervention addressed some of these difficulties there is a need for further intervention. However, what is interesting to consider is whether a process such as final consonant deletion is one of the 'realisation rules' described by Dodd (1995) or whether final consonant deletion is a description for the behaviour that results from a motor programming deficit. Researchers have debated the meaning and psychological reality of terms such as 'realisation rules' and 'phonological processes' for many years (e.g. see Hewlett, 1990; Harley, 1991). While they are undoubtedly useful descriptive terms of children's speech behaviours, the ways in which they fit with psycholinguistic processing levels remains unclear. Certainly Dodd and McCormack's (1995) model is one of the few to explicitly include 'realisation rules' as a processing level.

In Rachel's case intervention effectively addressed motor programming, as evidenced by her appropriate non-word repetition following intervention. Rachel's difficulties with motor programming were specific and high level: she had difficulties producing sequences of clusters. Her motor programming was efficient but required 'fine tuning' at an advanced, phonemic level. Rachel showed further generalisation: her treatment targeted three specific [s] clusters used in word final position, with generalisation noted to other untreated [s] clusters, untreated singleton [s] in all word positions and to some extent to other untreated fricatives. Again, this information provides some evidence for how lexical representations may be stored, but should be interpreted with caution given that this widespread generalisation was limited to just one child. On the one hand, the generalisation to singleton [s] and other [s] clusters may be a reflection of the neighbourhood effects of Rachel's phonological knowledge. More efficiently, or possibly working in conjunction with this effect, is motor programming and changes in the process of phonological encoding. If one considers that phonological encoding involves selection of a frame, and then the filling of the slots with appropriate units, addressing clusters involves working on the frame itself as well its contents, and thus it is not surprising that there is generalisation to clusters as a whole. This point is returned to in Chapter 11 in the discussion of efficiency.

Generalisation was minimal for Ben, and his overall generalisation patterns did not fit in with those of the other children. The question of why such minimal generalisation occurred for this child has been considered in some depth in Chapter 8. Ben did respond to intervention in a way that fits in with the model, but his generalisation to *other* items beyond these was minimal, suggesting that there may be additional factors at play: his age, intervention dosage and the range of different speech processing problems for different phonemes.

1.1.2 Across-task generalisation

Across-task generalisation for each child is summarized in Table 10.2. Ben's intervention was designed so that it tapped into almost all parts of the speech processing system: in intervention Ben carried out reading, auditory discrimination, speech and spelling tasks. Because intervention directly addressed each of these areas, there were no untreated tasks by which to measure across-task generalisation.

Table 10.2
Summary of across-task generalisation for each child

Child	Across-task generalisation	
	Yes	No
Oliver	From input (auditory discrimination and phonological representations judgement) to ▪ Output (single word naming and repetition) ▪ Spelling	
Katie	From output (single word speech production) to ▪ Spelling ▪ Input (auditory discrimination)	From output (single word speech production) to ▪ Output (connected speech production)
Joshua	From mapping (input and output) to spelling	
Rachel	From output (single word speech production) to ▪ Spelling ▪ Input (auditory discrimination) ▪ Output (connected speech production) From input (auditory discrimination) to ▪ Output (single word naming and repetition) ▪ Output (connected speech production) ▪ Spelling	

The extent of this generalization is fairly large compared to other studies (e.g. see Table 1.7). One of the reasons for this may be methodological: for each child a wide range of outcomes measures was selected to give the greatest chance of observing such effects. Glogowska (2001) has noted:

> "what shows up in terms of change... largely depends on what you chose to measure and how you measured it in the first place." (p.7).

Intervention was carried out over a fairly long timescale so that again, opportunities for generalisation were maximised.

None of the children in this study were treated primarily for literacy deficits, although many of the children had literacy difficulties and most of their programmes incorporated written forms in some way. However, all the children evidenced across-task generalization from either speech input or output to spelling. In most cases this was specific to items targeted in intervention rather than being general gains in their literacy that may have occurred through classroom instruction. It seems that spelling improvement typically occurs hand in hand with speech (or speech input) gains. This suggests that spelling is intrinsic to the speech processing system: by no means a novel finding. Spelling has not always been included as an outcome measure in evaluations of speech and language therapy, and for this reason may not have been widely noted. Stackhouse and Wells' (1997) detailed conceptualization of the lexical representation (Figure 2.3 in Chapter 2) accounts for this phenomenon in each child's case. This model shows arrows linking phonological representations to orthographic programmes, which can account for the fact that a very specific set of orthographic representations improved even in cases where children were not shown printed forms of words, i.e. bottom-up processing took place. It can also account for the way in which orthography, when included in intervention, may have supported the development of other skills, i.e. top-down processing took place.

Joshua's intervention aimed to improve his production of word initial clusters, by using written stories to introduce new cluster words. By the completion of intervention, he was able to produce the novel words with significantly improved levels of accuracy. Table 10.2 shows too, that across-task generalization extended to spelling. He had stored orthographic representations, accurate motor programmes and phonological representations, yet he lacked semantic and grammatical information about the novel words: he could not say what the words meant or use them appropriately in sentences. It is interesting to note that Joshua stored the orthographic programmes as whole units and was able to produce them by drawing on these stored programmes. This suggests that semantic information (and grammatical knowledge) is not a prerequisite for acquiring the other aspects of word knowledge. Although semantics is often presumed to be at the heart of young normally developing children's word learning (Chiat, 2000), older children have to deal with many new words, the meanings of which are acquired at a later stage.

Katie's intervention resulted in generalisation from her output therapy to input tasks not specifically addressed, such as auditory discrimination. In fact the changes noted in input were greater than those observed for output when compared to her peer group. Interpretation of this generalisation can be accounted for in several ways. Firstly, Katie's auditory discrimination skills were periodically reassessed between each phase of intervention, and this exposure at the assessments may have been sufficient to improve her auditory discrimination skills. She was periodically reassessed on both her non-word and real word discrimination, yet it was only in terms of her real word discrimination that she improved, suggesting that learning effects are not the sole factor at play. Another, more likely account, is that although intervention aimed to target output primarily, input was also addressed to some degree by the very act of child and therapist speaking to each other in intervention sessions. Intervention gave Katie opportunities to listen to the therapist's production of a specific set of words on an intensive basis, as well as listening to her own productions and being given feedback about these. It is extremely challenging to find *truly* untreated tasks that can be used to evaluate across-task generalisation. However, there may be evidence from Katie and the other children in the study that (a) input is more receptive to change, irrespective of whether or not it is specifically treated, and this ties in with (b), the fact that all the participants had difficulties with motor programming which may represent their core deficit and one that is very resistant to change. These claims are considered in further detail in sections that follow, together with an attempt to understand the nature of the link between auditory discrimination difficulties and motor programming.

In Oliver's case generalisation was noted from the input tasks that constituted the bulk of his therapy to his speech output. However, the final stage in Oliver's task hierarchy *did* involve speech production, and thus input and output tasks were not entirely separated. Again, it is interesting to note that the input programme was successful in improving input aspects targeted and brought some success in output too. Waters et al. (1998, 2001) also used input work successfully with a child with severe output problems in the presence of relatively good input skills (see Chapter 4). In Rachel's case intervention involved concurrent treatments of input and output, with widespread across- task generalisation resulting. Although this makes it hard to single out the specific effects of input and output work, it does show that working on the speech processing system as a whole (i.e. input and output) can result in changes for the speech processing system as whole.

It is equally important to consider cases where across-task generalisation did not take place. In Table 10.2 it can be seen that for Katie this did not happen from single words to connected speech - at least until connected speech was specifically addressed. This informs our knowledge about the relationship between motor programming, typically thought to take place at a single word level, and motor planning which is thought to move beyond single words focusing on the utterance as a whole. Although there may be clear links between the two, this does not necessarily mean that change in motor programming will filter down to the motor planning stage. Stackhouse and Wells (1997) consider that it is at the level of motor planning that the utterance is put together, although there is earlier input from the grammatical representations. Levelt's (1989) model incorporates grammatical aspects with connected speech by means of a 'formulator' which contains subdivisions for grammatical and phonological encoding with links between the two as well as with links between both these subsystems and the lexicon. In any event, based on the data from Katie's intervention it seems that if motor planning is to be improved then this process needs to be specifically addressed in intervention. In Katie's case the motor programmes need to be used in connected speech in a carefully scaffolded way. The fact that motor programming was addressed is not *necessarily* sufficient in resulting in feed forward to motor planning. This may be the case for children such as Katie with very severe difficulties as well as other concomitant motor execution difficulties. In Rachel's case generalisation from single word speech production to connected speech was noted without specifically addressing this aspect.

1.2 Modularity

Modularity is an important concept in cognitive neuropsychology, and one on which intervention studies may be able to offer insights. Harley (2001, p.21) has suggested that

> "We should start with the assumption that processes are modular or non-interactive unless there are very good reasons to think otherwise."

This was the approach adopted for this study. Results of the individual cases have not provided strong evidence against modularity of processing aspects. There is evidence for most of the functionally distinct components as they appear in Stackhouse and Wells' (1997, 2001) speech processing model. This evidence is evaluated in further detail in the points below. There was support from the intervention cases for the following:

- *Two distinct but closely linked phonological lexicons, an input store of phonological representations and an output store of motor programmes*. This is not a controversial notion and is well supported by experimental findings (e.g. Chiat, 1983; Hewlett, 1990). Each child's phonological representations and motor programmes were tapped by means of specific tasks. Differences were found in the extent and nature of the knowledge in each of these stores suggesting that they are functionally distinct representational spaces. Similarly, these stores responded in different ways to intervention, e.g. Oliver's intervention tapped his input phonological representations which improved more noticeably than his motor programmes.

- *A store of orthographic representations closely linked but separate from phonological representations.* Evidence comes from the way in which, for example, Oliver seemed to have no orthographic representations of words at the start of the intervention, in the presence of some inaccurate phonological representations. At the completion of intervention he had significantly improved phonological representations (of specific words) and had developed some orthographic representations of these specific words despite no direct exposure to written forms of the words in intervention. This has been suggested in other studies, for example Stothard et al. (1996) and Lundberg (2002).

- *Distinct stores of orthographic programmes and motor programmes.* Rachel, Katie, Ben and Joshua seemed to have more accurate knowledge of written forms of words than spoken productions at the initial assessment. Oliver made some improvement with his spoken productions as a result of intervention, but his written representations had improved to a greater extent. It is suggested that since his motor programming was problematic, he compensated by ready acquisition of visual forms. Since he was not shown written forms of the words, he was not learning whole orthographic forms but must have been building these based on his phonological recognition and representations.

- *A distinction between the phonological encoding of motor programming and the phoneme-grapheme conversion process required for writing.* Although there are similarities between these processes, they must be distinct as evidenced for example, by Oliver's readiness to develop new orthographic programmes but his inability to develop motor programmes in such a systematic manner.

- *A distinct semantic lexicon that is not automatically implicated in the speech processing of children with speech and language difficulties.* Joshua readily acquired new words and was able to produce and spell these with some accuracy, without fully acquiring and remembering the meaning of the words. While the semantic system has strong links to other parts of speech processing and can be useful in supporting aspects of speech and language processing in a top-down fashion (e.g. in Oliver's case), it does not necessarily need to be involved, and this is evidence of its functional separateness.

- *A functional distinction between motor programmes (single word) and motor planning (single word or connected speech).* Katie's response to intervention suggests that while there may be strong links between the two, targeting the former will not necessarily bring about changes in the latter, which requires more specific intervention addressed to its particular functions.

- *A functional distinction between real and non-word discrimination.* This was evidenced by selective improvement of these skills (e.g. in Katie's case). This does not necessarily mean that distinct boxes need to be included on the speech-processing model since the model can adequately account for these discrepancies by positing different processing routes (top-down in which case lexical representations are accessed, versus bottom-up, in which case they are not).

Each of these points relate to the Stackhouse and Wells (1997, 2001) speech processing model, a model which attempts to account for the way in which normally developing children process and produce speech. These authors suggest that if we have a model of what takes places when normally-developing children process speech, then this can be used as a starting point for understanding children with difficulties. The evidence cited above derives from children with speech and language difficulties, but contributes to the model of normal development. This is because a model of speech and language processing should be able to account for all cases, both normal and disordered.

> "A theory or model of a particular cognitive function is meant to account for all reported cases of disorder of that function, so that the theory is not a theory of a single patient." (Ellis and Young, 2002, p.9)

While there is some evidence for the distinctiveness of these modules, this is not to say that there are no links between the various subcomponents. For example, there is evidence of links between phonological representations and motor programmes, as evidenced by the 'decreasing gradient of knowledge' between the two, i.e. all children knew more about the sound structure of words than they could produce, both at the start and completion of intervention. This suggests that the main flow of information may be from phonological representations to motor programmes. Links between phonological representations and orthographic representations have similarly been illustrated, e.g. Oliver was able to map from his phonological representations to create new orthographic representations. Orthographic knowledge, once established, can be used to support other aspects of speech processing, e.g. Rachel and Joshua's intervention programmes relied heavily – and successfully - on this top-down flow of knowledge. This supports the links hypothesised by Stackhouse and Wells (1997) and shown in Figure 2.3.

In Chapter 2, Seron's (1997) considerations about multiple baseline designs and their need to be used with functionally distinct tasks, were presented. This constraint was noted in many of the children's intervention designs - which in itself yields insights into modularity. For example, Joshua's programme distinguished between consonant clusters with different sets of clusters targeted in consecutive intervention phases. However, by completion of the first phase of intervention many of the untreated clusters had improved, presumably through the fact that some clusters were being addressed and links between all clusters exist. The exact nature of these links remains unclear: Is it at the level of phonological encoding that the commonalities exist or in the way in which words are stored as motor programmes? Rachel's intervention also resulted in generalisation from treated to untreated clusters. Pre-intervention, she had the concept of a cluster but had difficulty in consistently representing and ordering the segments (again evidence of phonological encoding difficulties). After intervention this aspect improved for the treated clusters as well as for other untreated clusters. In Rachel's case the treated and untreated clusters were all [s] clusters and thus the relationship between these clusters may be even closer than that for all consonant clusters more generally.

Modularity can also be considered more broadly, for example, considering whether speech and language skills function in a separate way to cognitive skills more generally. This was a question not systematically investigated in this work, although there are still insights to be gained into the issue. The first is through consideration of the children's non-verbal IQ scores. If language skills are separate from other non-verbal cognitive skills, as some authors have suggested (Chomsky, 1980), then children's non-verbal scores would have no bearing on their language skills or their response to therapy. This is exactly what was found. For example, Ben was the child with the highest non-verbal IQ at 115, yet he had widespread speech and language difficulties and his response to intervention was positive but with minimal generalisation observed. Rachel has an average non-verbal IQ of 100. In Chapter 7 she was cited as an example of a resilient child, not conforming to predictions of Bishop and Adams' (1990) critical age hypothesis and able to respond very positively to a relatively short period of intervention. Katie and Joshua are children with borderline non-verbal IQ scores in the presence of widespread language processing problems. Both children responded well to intervention. There was no relationship between the children's IQ scores and their difficulties and responses to intervention, which may suggest that language is indeed a modular aspect of more general cognition. However, there are more general aspects of cognition such as attention, memory and reasoning which were important skills that the children brought to intervention.

1.3 Refinement of Stackhouse and Wells' speech processing model

Stackhouse and Wells' (1997, 2001) speech processing model is able to account for the five cases both in terms of assessment findings, as well as changes following intervention. Thus, the model successfully meets the "minimum requirement for any model... that it should be compatible with the data under consideration" (Stackhouse and Wells, 1997 p.144). However it is acknowledged both by these authors, and by others more generally (e.g. Baker et al., 2001; van Dulm, 2002) that psycholinguistic models are underspecified, gross accounts of the intricacies of speech and language processing. The intervention studies carried out suggest two specific aspects of the model which would benefit from further expansion: motor programming and the speech-language interface. These are discussed below:

1.3.1 Motor programming

Motor programming problems are widespread in the older group of children with persisting speech difficulties. Both in this study and in other research (e.g. Ozanne, 1995; Nathan, 2001) motor programming has been cited as a particular source of difficulty for children with speech problems. Stackhouse and Wells' model specifies one 'box' for this process. Given the range of difficulties found in the five children in this study, it is suggested that there is some evidence that further specification of this level is needed. Three of the five children who experienced difficulties with this level of processing demonstrate the range of difficulties (and thus levels of processing) that should be included in the model.

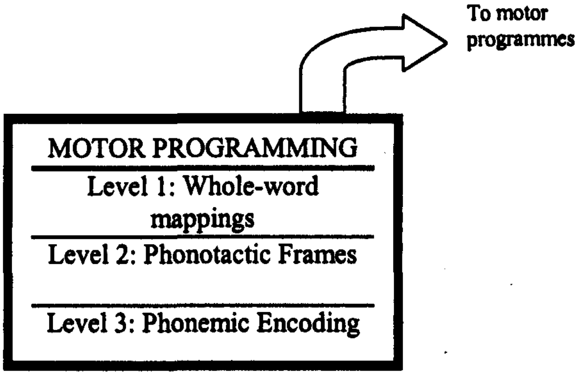
(a) Oliver's online motor programming was severely impaired. He was able to program new words by using an (inaccurate) *whole word mapping* technique, directly from his phonological representations to his motor programmes.

(b) Katie's motor programming was also severely affected but over the course of intervention she was able to program new words more accurately by setting up the correct CVC *phonotactic frame.*

(c) Rachel's motor programming was more intact than the two children above. She was able to alter her programming ability over the course of intervention by re-ordering specific *phonemic segments.*

It is suggested that these three levels of processing be included in any conceptualisation of motor programming. Stackhouse and Wells' (1997, 2001) model is right in that it places motor programming off the main processing route – it does not always occur and there are other routes for speech production which need not call upon this one. Oliver did not yet have *any* access to motor programming: he used an alternative 'direct route' shown in Figure 10.1 since he had no functional motor programming skills available to him. Alternatively, if motor programming is conceptualised in a hierarchical 3-tiered way (as shown in Figure 10.2) then it could be said that he does have access to motor programming but that his skills are still at a very simplistic, 'shallow' level.

Figure 10.2
Further specification of Stackhouse and Wells' motor programming module



Katie programs at the level of phonotactic frames while Rachel has access to the deeper levels of motor programming involving phonemic encoding. The suggestion of these levels is not a novel one. It is closely linked to Hewlett's (1990) conceptualisation of motor planning as consisting of syllabic and segmental levels; Levelt's (1989) description of phonological encoding; and the lexical restructuring accounts such as Metsala and Walley's (1998) outlined in Chapter 2. Furthermore, developmental studies of input processing have suggested a similar 'weighting shift' in terms of perceptual processing from big (i.e. words and utterances) to small (i.e. segmental) units (Nittrouer et al., 1989).

1.3.2 The speech and language interface

Most models do not account for all the aspects involved in speech and language processing, and choose to focus on specific parts of the process. Stackhouse and Wells' (1997, 2001) model focuses mainly on speech processing with the authors noting:

> "Although [the model] attempts to handle the processing of connected speech and the influence of phonetic context, it does not deal in any detail with sentence processing and grammatical development. Within this limitation, it attempts to be reasonably comprehensive." (p.146)

However, this separation of speech from language may be problematic in that aspects crucial to understanding the entire process of speech and language are oversimplified and incomplete. Paul (1998) and Camarata (1998) emphasise the speech-language connection suggesting that it is inaccurate to view speech and language as autonomous processes, and that the speech-language connection should be taken into account when evaluating models of speech and language processing. These authors give wide-ranging examples of the links between speech and language. Of particular interest to the present study are the following: (1.3.2.1) phonology and syntax links, (1.3.2.2) phonology and semantics links, and (1.3.2.3) 'choke point' theories of speech.

1.3.2.1 Phonology and syntax links

In terms of phonology and syntax it is noted from experimental work that syntactic complexity frequently results in reduced phonological accuracy (e.g. Panagos and Prelock, 1982; Paul and Shriberg, 1982). This is thought to occur because of limited processing resources so that increased syntactic processing demands result in decreased resources available for phonological processing, and the fact that there is a shared interface between phonology and syntax. In the present study, much of the assessment and intervention focused at a single word level. When performance on single words was compared to connected speech production, children's speech was typically found to contain more errors in the connected speech (e.g. if one contrasts the children's performance on a single word naming test and in a connected speech task such as the Bus Story (Renfrew, 1969)[24]. If one considers this relatively well-accepted fact, then it must indicate that grammatical processing (or encoding) is taking place prior to phonological encoding since the earlier process depletes resources for the later one. Indeed this is what Levelt (1989) hypothesises in his model.

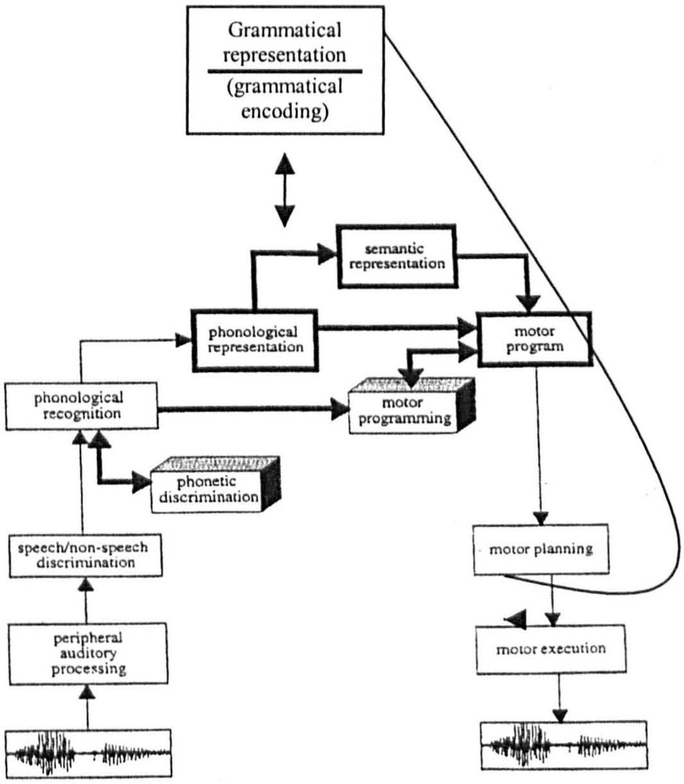
There are some problems with Stackhouse and Wells' model with its emphasis on speech processing, in accounting for these speech-language links. The model does not explicitly considered how grammatical representations tie in with other aspects of connected speech processing. The model is largely an account of single word processing, although motor planning is explained by considering connected speech. So, in terms of the model, where does connected speech come from and how does the processing load of connected speech production affect the system? Where is the interface between grammar and speech? There is some evidence that developmentally, children move from big (i.e. connected strings

[24] However, the reverse was found in the intelligibility study where children were found to be more intelligible in their connected speech production than their single word production. Although there may indeed have been more errors in their speech output for connected speech, the listeners were able to draw on their grammatical and semantic knowledge.

of words or single words) to smaller units (syllables or segments) in their speech processing – how is the system differentiated to cope with these differences? Stackhouse and Wells consider that the lexical representation includes grammatical information about, for example, the part of speech of a particular word and the type of plural form it takes. However, it is unclear where grammatical encoding takes place, if one is moving beyond a single word utterance. Grammatical encoding seems unlikely to take place at the motor planning level as this does not fit with what is known about the resource issue, i.e. that grammatical encoding must occur before phonological encoding if the former is to deplete the resources available for the latter. If grammatical encoding takes place at a higher level, for example, it is included in the box entitled 'grammatical representations' (see Figure 2.3) then it is unclear how this process would fit in with other aspects such as semantic knowledge and phonological encoding.

It is also not clear how Katie's pattern of response fits in with the model. Katie made significant progress with her single word speech production in the early phases of intervention, while her connected speech production remained unchanged. After intervention that specifically addressed her connected speech, her connected speech production improved while her single word speech accuracy declined (although it did not return to pre-intervention levels). In the first instance it may have been that she had revised motor programmes for the treated words, but when required to produce connected speech her accuracy decreased due to resource limitations. However, Katie was asked to produce single words in a standard carrier phrase and thus did not have to generate her own grammatical formulations. Because of this fact it has been hypothesised that motor planning was being tapped, both in intervention and assessment. The issue remains of where grammatical encoding takes place, how this links in with phonological encoding and other aspects of the model, particularly with motor planning. The model is focused largely on single word representations *until* the level of motor planning. Clearly this is not the case, and the authors have described the model in terms of the *best* exemplars of linguistic processing units in each module. It would be useful to develop the model to include grammatical encoding. Chiat (2000) explicitly incorporates grammar into her model of children's speech and language processing. Verbs and their associated argument structure lie at the heart of her model of grammatical processing whilst integrating with other aspects of speech and language processing, making it a fairly comprehensive developmental model in terms of the speech/language interface. It is suggested that Stackhouse and Wells' grammatical representation box should be expanded to include (an optional) grammatical encoding box for utterances. Strong links already exist between that box and semantic knowledge. Since motor programmes are typically thought to be stored at a single word level, links could then be conceptualised between grammatical encoding and motor planning, i.e. grammatical encoding generates a frame for the utterance with semantic representations and motor programmes then retrieved at a single word level and brought together to fill in the pre-created frame at the level of motor planning. These hypothesised additions to the model are shown in Figure 10.3.

Figure 10.3
Speech processing model adapted from Stackhouse and Wells (1997) to explicitly include grammatical encoding and links with motor planning



How does this help explain Katie's response to intervention? The decrease in the accuracy of her single word production remains hard to explain in the presence of the increased accuracy of her connected speech production. Some accounts were given in Chapter 5, and it seems likely that a combination of factors may best explain the phenomenon: pragmatic factors, metalinguistic awareness and the work on motor planning causing Katie to focus on larger chunks of speech rather than single word processing. Her intervention initially focused on updating her motor programmes which did not result in any connected speech improvement. However, introducing the target items in carefully graded sentences for her to produce would have stimulated her grammatical representations and grammatical encoding, and this, together with the strong links posited between grammar and motor planning may have resulted in the positive changes that occurred for connected speech. Thus, the suggestion made previously, that working on motor programmes will not necessarily affect changes in motor planning, is strengthened if we consider that motor planning (at least at a connected speech level) relies on strong links with grammatical encoding and its top-down influence. Gordon and Luper (1989) found that syntactic complexity results in decreased fluency in young children. The links suggested between grammatical encoding and motor planning would be able to account for this observation, in the context of a limited resources model.

1.3.2.2 Phonology and semantics links

Links between phonological representations and semantics are also an important part of the speech-language interface. These are links that *are* explicitly included in the Stackhouse and Wells' model. Joshua's responses to his intervention programme suggest that such aspects should be carefully considered in conjunction with more specific linguistic aspects. His intervention addressed his phonology, specifically his production of clusters, by focusing on novel words. Because of his behavioural difficulties the words were introduced in the context of social stories. However, Joshua's profile of speech, language and behavioural difficulties is complex. He was perhaps given too much new information to process in his intervention. Although he did make progress with his phonology, he did not remember the meaning of many of the new words. His phonology improved more for the familiar control words than for the unfamiliar words that formed the focus of intervention. Camarata and Leonard (1986) carried out studies that revealed that increased semantic complexity resulted in decreased phonological accuracy. Leonard et al. (1982) found that new-word learning involving new phonemes was more challenging than new-word learning involving already acquired sounds. Joshua's response to intervention replicates the finding since the words used in therapy were not only novel but also in many cases highly abstract.

The links between semantic knowledge and motor programmes are clear in Stackhouse and Wells' model. Yet in order to account for responses such as Joshua's to heavy semantic processing loads, one has to assume that the child's speech processing system has a finite processing capacity with the hypothesised modules working together in an additive way. At a certain point the child's threshold for optimal learning will be exceeded. This is akin to Crystal's (1987) 'bucket theory' in which an extra drop of, for example, phonology is thought to cause the bucket (the child's processing system) to overflow, thus compromising some other aspect of language processing. This assumption is not made explicit by Stackhouse and Wells – although it must be noted that most information processing models do not explicitly consider this in their design.

1.3.2.3 Choke point theories of speech

Speech is a vitally important aspect for shaping and organising the language system. There is some evidence, mainly from children with little or no functional speech, that not being able to produce speech results in widespread language problems (e.g. Blischak, 1994; Camarata, 1998). It has been suggested that:

> "Speech can serve as a choke point or flow restrictor for the other aspects of language." (Camarata, 1998, p.312).

In other words, children must be minimally proficient in speech production in order to be successful in overall language production[25]. How does this fit in with the children in this study and with Stackhouse and Wells' account of speech processing? There were two children in the study with very severe speech production problems: Katie and Oliver. Oliver not only had output problems with his motor programming but also had auditory input difficulties: he suffered from ongoing middle ear infections when younger. Katie may be a better example of this theory since her speech output difficulties are pervasive and linked to her ataxic cerebral palsy. Indeed, the rationale behind her intervention planning was that her speech problems are a core deficit and addressing these – the *cause* of the other speech, language and literacy problems – would result in improvement of the other aspects. The theory was partially proved since the gains made in her speech resulted in gains on the input side of the profile and improvements in her spelling – but more widespread generalisation to other aspects of language processing was not seen. This may have been because the intervention dosage was not sufficient and that given more intervention such patterns of change would be seen. This 'choke point' theory may be another way of looking at what has already been described: all the children in this study experienced varying degrees of speech, language and literacy difficulties. What they all had in common is a difficulty in their speech production, or more specifically with their motor programming. Motor programming may be the flow restrictor that gives rise to more global difficulties, e.g. new word learning, speech and spelling.

The logic used in Katie's case may not necessarily be the best way of testing whether the 'choke-point' is the cause of other problems in the system. Although it may well be the *cause*, it may not be the module most amenable to *change*. Results of the case studies presented here have shown that whatever the cause of speech and language processing difficulties, input modules may be more amenable to change and in many cases

[25] Hearing-impaired children proficient in sign language pose an interesting challenge to these theories that emphasise speech production. It may be that any complex motor activity that interfaces with language is sufficient to prevent the 'choke-point' occurring, i.e. articulatory or hand gestures.

the best starting point for making long lasting changes in the speech and language processing system. Stackhouse and Wells' model can adequately account for the choke point theory of speech. These authors conceptualise close feedback between speech output and input. If output is severely disrupted, intra-individual input will be less and the opportunities to develop and revise speech processing minimised. In this model there is less feedback posited than for models such as Hewlett's (1990). Hewlett (1990) conceptualises feedback between almost all levels of speech output. These feedback links enable one to explain the importance of speech output and the effect it must have on the entire system.

2. DEVELOPMENTAL PHASE MODELS

Some authors do not agree with the application of static cognitive neuropsychological models to children since their speech and language is developing in a dynamic way (e.g. Frith, 1985; Bishop, 1997). Much has been written about the importance of adopting a developmental perspective when attempting to understand children's development of speech and language both in normally developing children and in children facing difficulties (e.g. Karmiloff-Smith, 1998; Chapman, 2000; Evans, 2001). Stackhouse and Wells (1997, 2001) have also emphasised the developmental perspective. The speech processing model discussed in the previous section is one aspect of a broader psycholinguistic framework which includes a developmental phase model (shown in Figure 2.4). These authors consider the developmental phase model to be as important as the information processing model, with each one offering different but complementary perspectives on children's speech and language processing. The information processing model enables one to evaluate how children cope with different aspects of speech processing and at which specific points they are experiencing difficulties. The developmental phase model, on the other hand, allows one to consider a more longitudinal perspective: what is the child's current level of development in relation to the endpoint which they need to achieve, and in relation to developmental norms?

The importance of the developmental model became apparent when attempting to explain some of the responses of individual children to intervention. Much has been made in previous sections of this chapter and in the children's chapters about the different levels of motor planning: from whole words to phonotactic frames to individual segments. Figure 10.2 shows these different levels of mastery in terms of motor programming. Essentially, this is an attempt to combine a developmental phase perspective with a static information-processing model. Including three differentiated, hierarchically ordered levels of motor programming reminds one that motor programming is carried out in different ways at different phases of development. This represents what happens in normal development, and is a useful way of understanding children's difficulties. As has been noted about Frith's (1985) developmental stage model of literacy:

> "Frith's approach helps us to see children with... difficulties in a more positive light. They are not 'disordered' or fundamentally different from normally developing children, but in certain aspects of their development they have not moved onto the next phase in the way that studies of normally-developing children lead us to expect." (Stackhouse and Wells, 1997. p.188)

Stackhouse and Wells' (1997) developmental phase model describes a whole word phonology phase through which children initially pass and which can be linked in terms of literacy to Frith's logographic stage. This fits in well with what has been found about children's language processing from the earliest developmental stages. For example, Maassen (2002) suggests that in box-and-arrow terms, children may initially move from selection of a whole word motor programme (or lexeme) to motor planning, skipping out phonological encoding (motor programming) which is concerned with phoneme specific mappings. As has been previously mentioned, Oliver is a good example of a child who seemed to be stuck at this phase. Linking in with Frith's (1985) model of literacy development, it is shown that Oliver is similarly stuck at the logographic stage in his literacy. He exhibits non-phonetic spelling errors and visual reading errors. By the completion of intervention, Oliver still seemed to be based largely at the whole word level of speech, but he was certainly showing signs of having progressed further in terms of his literacy development towards the alphabetic stage. This provides some evidence of the 'choke-point' theory of speech development described in the previous section. Although he is restrained by the motor programming 'choke point' in terms of his speech, his spelling is not subject to output constraints and is slightly further advanced.

Katie is another child based primarily at this whole word phase of development. In contrast to Oliver she *did* show some patterns (e.g. stopping) characteristic of Stackhouse and Wells' (1997) systematic simplification phase. In her case it was developmentally appropriate to focus intervention on the earlier whole word phase. Again, it is helpful to view the developmental phase model in conjunction with the information processing model since systemic substitutions may occur at different points in the system, e.g. in Katie's case due to both phonological recognition difficulties and motor programming problems. Katie was supported to move from the whole word phase into the systematic simplification phase, and further intervention will be required to consolidate her skills at this level before moving her onto the assembly phase. Her literacy progress is in line with her speech development:

she shows some attempts at alphabetic representations but has not fully mastered this level of processing.

The systematic simplification phase is followed by the assembly phase in which children are required to combine together various aspects of their linguistic knowledge. Stackhouse and Wells note that difficulties at this level may be indicative of motor programming or motor planning problems. At its highest level, motor programming requires children to sequence together phonemes (e.g. see Figure 10.1). Motor planning involves combining words into connected speech, with co-articulation, prosody and fluency coming into play at this level. Rachel can thus be seen as a child whose difficulties mainly centre around the assembly phase. Her pattern of difficulty does not entirely accord with the developmental model. One of the model's assumptions is that children need to acquire the skills associated with one phase before they can progress to the next phase. Although Rachel's main difficulties are with the assembly phase, she is not stuck here and has excellent metaphonological skills characteristic of the *next* stage of development. Her literacy skills are excellent and she evidences good alphabetic and orthographic skills. It may be that at each of the phases there is a minimum threshold of skills to be achieved which allows the child to progress to the following level. Rachel's assembly difficulties are very specific ones, and thus she may have had sufficient core assembly skills to allow her to go on to develop metaphonological skills and associated literacy skills in the normal way. Another alternative is that she may have been stuck at the assembly phase, but (previous) intervention and the work carried out in class has addressed her metaphonological skills allowing her to compensate for the specific difficulties with assembly.

Developmental phase models do not necessarily have the degree of specificity associated with information processing approaches, yet they offer important insights into children's development. Stackhouse and Wells' framework with its inclusions of both types of models provides a comprehensive way of understanding children's speech and language development. It is interesting to note that the box-and-arrow model from Stackhouse and Wells has been used in a great many case studies (e.g. Stackhouse and Wells, 1993; Constable, Stackhouse and Wells, 1997; Vance, 1997; Ebbels, 2000) but that the developmental model is seldom applied. Although there is increasing awareness of the importance of a developmental perspective as emphasised by authors such as Bishop (1997), Karmiloff-Smith (1998), Chapman (2000) and Evans (2001), the explicit adoption of developmental phase models in intervention research has been limited to date. This may be due to the lack of specificity that such models seem to offer in terms of intervention planning: although one can pinpoint where a child is on the developmental trajectory, and relate this to where a child needs to be in relation to their peers, this does not tell one how to help move the child there. Although the same has been said of information processing models (e.g. see Howard and Hatfield, 1987) the present research has aimed to show that information processing models can feed directly into intervention planning at least in terms of process (the 'how' of therapy) if not for the content (the 'what' of therapy). The issue of intervention planning and the practical utility of models is a *clinical* issue, discussed further in the following chapter. If our aim from a theoretical perspective is to understand more fully how children process speech and language, then we have to consider the developmental phase perspective but without losing the detail included in information processing models. One way of combining the two is by means of the inclusions of different depths or levels of processing as shown in Figure 10.1 for the motor programming module.

3. THEORIES OF DISORDER

This section returns to some of the theories of speech disorder presented in Chapter 2, to evaluate them in the light of the data presented in Chapters 4-8. The theories forming the focus of this section include (3.1) motor programming theories, (3.2) mapping theories (3.3) auditory theories, and (3.4) sub-grouping and profiling approaches to understanding children's difficulties.

3.1 Motor programming theories

The five children were selected according to broad criteria outlined in Chapter 3: they were all school-age children with persisting speech difficulties. While much was made of the heterogeneous nature of children with speech difficulties, there were striking commonalties between the speech processing profiles of the five children. All five children were found to have difficulties with their stored motor programmes and online motor programming, although the extent and severity of the difficulties varied. Locating persisting speech difficulty as a deficit of motor programming fits in with the literature on motor programming / motor planning difficulties and 'choke-point' theories of speech discussed in the previous section of this chapter. For example, Ozanne (1995) studied a group of 100 children aged between 3;0 and 5;6 years of age with specific speech and/or language difficulties. She reported a high incidence of motor programming difficulties.

Motor programming difficulties are thought to characterise developmental verbal dyspraxia. Children in this study were not specifically labelled as dyspraxic, mainly because the psycholinguistic approach is an attempt to move away from descriptions of surface speech difficulties, and considers that a specific diagnosis (e.g. dyspraxia, hearing impairment) is not necessarily associated with a particular speech processing profile or intervention package. Furthermore, diagnosis of dyspraxia is controversial (Ozanne, 1995;

Shriberg, Aram and Kwiatkowski, 1997) with much disagreement about whether the condition exists as a distinct clinical entity, and if it does what its core characteristics are (see Chapter 4). From a clinical perspective, it is usually diagnosed by looking for clusters of deficits in speech output performance (Stackhouse, 1992; Campbell, 2002). The aim of this study was to look at children with persisting speech disorders more generally, and the assessment undertaken was towards a fundamentally different end. However, we do know that Rachel and Oliver had labels of dyspraxia applied to them at various points. Irrespective of whether one uses the label dyspraxia or not, all the children found motor programming problematic. Maassen (2002) suggests that from a cognitive neuropsychological perspective dyspraxia can be described beyond clusters of clinical symptoms as a difficulty in phonological encoding (i.e. motor programming) and that it can occur in conjunction with other difficulties such as dysarthria (such as in Katie's case) or autistic spectrum disorder (as for Joshua). Ozanne's conceptualisation of dyspraxia as affecting the multiple processes of phonological planning, phonetic programme assembly and execution, is a useful one which can account for why dyspraxia is so often resistant to intervention (Ozanne, 1995).

All the children had motor programming problems, yet it is hard to separate out cause and effect. Has motor programming resulted in other processing problems, or are the motor programming problems the result of others deficits in the system? Intervention studies can assist in separating out cause and effect: if one successfully treats the (hypothesised) root cause, then one might expect the other difficulties to disappear. However, intervention is seldom so clear-cut: in the cases presented here, motor programming did improve for all the children but for the most part it was not fully remediated in the sense that children became comparable to their age-matched peers. Thus, if the root cause has not been fully addressed then one would not expect the other aspects to be fully remediated either. Rachel's case may be the most informative in this regard: intervention tapped her motor programming successfully, and at a macro level her motor programming was found to be age appropriate post-intervention. Her motor planning and her phonological representations had also improved, as well as her overall intelligibility. However, her intervention also included an auditory discrimination component (see Chapter 7), which confounds the issue. If one wanted to test this motor programming theory further one would need to carry out intervention that systematically (and only) taps motor programming, looking to see at which point more widespread changes are noted throughout the system. It is also unclear from follow-up studies whether all severe motor programming difficulties can ever be fully resolved (e.g. Gruber, 1999; Le Normand ,Vaivre-Douret, Payan and Cohen, 2000). This would make it impossible to ever test out the theory in the way suggested. More efficient interventions might focus on addressing other aspects more amenable to change that offer the child some compensation.

3.2 Mapping theories

Chiat's (2000) mapping theory states that children have specific difficulties with language because they fail in the mapping process, that is, mapping phonological input forms onto meaning from the earliest stages of language development. Difficulties with this mapping process are thought to result in widespread problems throughout the system, typically giving rise to SLI.

New word learning gives opportunities to evaluate this type of mapping. Rachel and Joshua were taught new words as part of their intervention programmes. Orthographic knowledge was made explicitly available to the children. They responded very differently: Rachel was skilled in mapping the new phonological forms onto meaning, as indicated by the way in which she was able to use the words appropriately on completion of the intervention. Joshua acquired the new phonological and orthographic forms with ease, but was not able to link these to meaning in any permanent way. Many of the words introduced in his intervention were abstract words, difficult to explain or illustrate with pictures, so it may not have been his mapping *per se* that was problematic. Rather, it may have been that the level of the words was beyond his current developmental level and Joshua perceived the pragmatic relevance of the words to be low.

Similarities between the five children's profiles have been mentioned in section 3.1 and Chapters 6 and 7. However important differences also exist. Three of the children had relatively strong phonological representations in the presence of auditory discrimination and motor programming difficulties. For these children, accurate phonological representations may have been built up by relying on semantic knowledge (or even orthographic knowledge) as a means of overcoming the 'lower level' input difficulties they face, i.e. semantic bootstrapping. The 'low-level' difficulties are not likely to work as a complete barrier but will necessitate a greater reliance on top-down processing than may be normal.

The type of mapping proposed by Chiat (2000) is difficult to evaluate from the present study and may not be wholly appropriate to the group of older children in question. Chiat's theory is concerned with early mapping processes that must take place in order for language to develop normally. Her theory is concerned in making links between the different types of input children receive, i.e. visual (semantic) information and auditory (speech) information. However, in order to produce meaningful speech, children must be able to map this input information (from a range of sources) onto an output motor programme. This mapping processing may be of more relevance to this older group of children with persisting speech output (motor programming) difficulties.

Despite the children's different profiles and their differing interventions, all the interventions involved some form of mapping from input to output, from phonological representations to motor programmes or motor programming. Typically this was successful for the treated words, indicating strong links between the two lexicons. However, two distinct pathways for mapping have been suggested (Figure 10.1): One is the direct route which would involve accessing a stored phonological representation and using this to access a stored motor programme, tapping into motor programming in a very shallow way. The other is the indirect route, typically thought to occur when processing of unfamiliar words is taking place. This entails linking phonological recognition to phonological encoding. The mapping interventions presented here were all effective but the extent of the generalisation varied considerably. This may be explained by considering that the children had a choice of two paths to carry out this mapping. Oliver, for example, made good progress with speech production of treated words. However, his generalisation to untreated novel words was minimal suggesting that no change had occurred in his phonological encoding processes but that he had been able to successfully store and more accurately produce the items that had been targeted in intervention. Oliver has minimally functional motor programming and relies on one-to-one mappings from input to output. The clinical implications of this are important: he can bypass the troublesome depths of motor programming, though it takes longer and is less efficient to learn new words by the more direct mapping route. The reverse is true for the adults described by Whiteside and Varley (1998). These ideas fit in well with current treatment theories: Dodd and Bradford (2000) suggest that children with inconsistent speech benefit from being taught a core vocabulary. This is one-to-one mapping of the type described, rather than expecting the child to generalise broadly from altered phonemic encoding. If one aims to tackle motor programming directly, rather than opting for compensatory techniques, then a programme such as the Nuffield Dyspraxia programme (Connery, 1992; 1994) could be used with careful consideration of the sequence of linguistic units addressed. This programme starts with phonemes and builds up to phrases. These children may in fact need to start with larger chunks of speech (at least words) and then move to smaller units. Another way of addressing troublesome motor programmes is by working on non-words or unfamiliar words. This was successful with Rachel, but less effective with Joshua, suggesting that processing demands may accumulate for these children and that some variables should be held constant rather than working on too many new aspects all at one time (i.e. phonology and semantics and pragmatics / social skills).

Katie responded with limited generalisation after her first phase of intervention. She effectively mapped more accurate phonological representations onto her motor programmes, but limited generalisation was noted to matched words. There is some evidence to suggest that this intervention was targeting her stored motor programmes directly with one-to-one mapping, because if motor programming had been altered then a new frame including final consonants might have been set up, and thus resulted in improved CVC words more generally. Katie had a subsequent phase of intervention that gave her the opportunity to hear and produce many more exemplars of CVC words, and this did result in generalisation to untreated CVC items. It is suggested that this was sufficient exposure to involve motor programming. Alternatively, she may have had some CVC words stored as motor programmes so that new templates were more readily available for phonemic encoding. Other children, like Rachel, had very specific difficulties with phonological encoding, which were more easily addressed and resulted in widespread generalisation after relatively little intervention. It seems clear that Rachel was at a different developmental level to the younger children such as Oliver and Katie.

Katie, Rachel and Joshua were three children for whom the notion of mapping from phonological representations to output motor programmes was strongly invoked in intervention. Interestingly, they were the three children who revealed significant improvements at the level of the profile on the input side. This may provide further support for two levels of mapping: input mapping (as described by Chiat, 2000) precedes mapping to output, and thus intervention focusing on the latter may result in changes to input processing before changes are seen in output.

Chiat's mapping theory provides a useful account of early language development and what might go wrong for children diagnosed with SLI. For children whose persisting speech difficulties seem to lie at the heart of their problems (in contrast with the grammatical difficulties associated with SLI), mapping problems – although of a slightly different type – may be the cause of their difficulties. However, the terminology 'mapping' may be simply another way of referring to motor programming. This still leaves us with difficulties in evaluating such theories due to confounds of cause and effect.

3.3. Auditory theories

Tallal's auditory deficit theory (Tallal et al., 1993; Merzenich et al., 1996) suggests that it is low-level auditory processing problems that cause the difficulties associated with SLI and other persisting speech and language problems. Specifically, it is suggested that these children have problems processing rapidly changing acoustic information, which results in cascading effects downstream through the language system. Debate surrounding this theory was outlined in Chapter 2 (section 3). The auditory deficit hypothesis is widely held to be an insufficient explanation for the wide-ranging difficulties children experience, and for all individual children's problems. The theory does however raise valuable considerations about the importance of input processing in general.

In the present study, a deficit common to four of the five participants was phonological recognition, or more specifically auditory discrimination of closely related real and non-words. Joshua was the only child whose phonological recognition was a strength. While the exact nature of the relationship between input and output remains debatable, there is evidence from an increasing number of studies that a proportion of children with persisting speech difficulties have auditory processing deficits (e.g. Bridgman and Snowling, 1988; Bird and Bishop, 1992; Nathan, 2001). Certainly, children with persisting speech difficulties may have input difficulties, but again it is difficult to separate cause from effect. Oliver's intervention focused primarily (although not exclusively) on input. The fact that his input processing improved significantly, *as well as* his output processing, underlines the importance of input in shaping the rest of the system. This ties in with what has been said about mapping from input to output, since if you are trying to map an inaccurate representation you will almost certainly produce inaccurate output. It was mentioned previously that whether working on input (as in Oliver and Rachel's cases) or output (as in Katie's case), input seems to be more amenable to change. It may not be surprising that working on output can have strong effects on input, when one considers that whatever children produce they hear and most therapy is conducted with the therapist providing auditory input to the child even if it is not being explicitly addressed. Another explanation may be that from a developmental perspective input processing happens before output productions. That is, input mapping must happen efficiently before input to output mapping can occur. Recent bio-behavioural studies provide some physiological evidence that parts of the brain used for processing input may indeed be more plastic than the areas subserving speech output. Results of a study by Temple et al. (2003) with children with dyslexia and oral language difficulties found that partial remediation of language-processing deficits, ameliorated disrupted function in brain regions associated with input phonological processing and produced additional compensatory activation in other brain regions.

There is some evidence, both diagnostic and from the intervention, that non-word discrimination and real word discrimination are separate skills carried out in different ways. Children such as Rachel showed a clear mismatch in the ability to discriminate between non-words and real words. Although to some extent this is normal (Stackhouse and Wells, 1997, 2001) the difficulties that she faced were far greater than what one might expect in a normally-developing child. Real word discrimination may be a top-down process that draws on semantic knowledge, whereas non-word discrimination must rely solely on bottom up processing without access to lexical representations, and would thus show up any difficulties with more basic auditory perceptual skills. Katie's intervention resulted in improvement in her real word discrimination but not her discrimination of non-words, suggesting that her lexical knowledge may have bootstrapped her auditory processing, making the real word discrimination easier for her.

For three of the five children there was not a neat correspondence between the parts of the speech processing system addressed and the changes resulting from intervention. Katie's motor programming was addressed, but it was with her phonological recognition that most change was noted. Joshua's motor programming was also addressed (the mapping process from phonological representations to motor programming) but it was his phonological representations that improved most considerably. For Ben, intervention targeted most parts of the speech processing system, but no changes were seen at the macro level of the speech processing model. Again, one needs to be clear about what it is that is being measured. Although each of the children's interventions was successful in addressing its specific targets, changes were only note at the macro level of the profile, if they were linked to chronological norms and extended beyond the specific set of treatment stimuli. Ben's intervention was not unsuccessful, but it did not seem to bring about widespread change in his speech processing system.

Clearer patterns of correspondence were noted for two of the children: Oliver and Rachel. Oliver had difficulties with phonological recognition, phonological representations, motor programming and his stored motor programmes. Intervention specifically addressed his phonological representations (as well as other parts of the input side). Changes observed at the macro-level in terms of the model were at the level of phonological representations. Rachel's intervention design was slightly more complex with different sets of words being treated in different ways. She had both input and output problems, and thus input treatment addressed phonological recognition and output treatment addressed motor programming. Macro-evaluation revealed that both these areas had improved at the macro level of the profile. Because of the design of her intervention, it is hard to separate out which parts of the intervention brought about those changes respectively. However, what is interesting to note is that there are correspondences between problems, targets and changes when intervention focuses on input. It seems that no matter what aspect of the speech processing profile is addressed, input changed most readily.

3.4. Sub-grouping and profiling approaches

Not all theories about speech and language disorder suggest that there is just one cause or primary locus for all children's problems. Many theorists suggest that there are likely to be many causes and combinations of factors resulting in children's speech and language difficulties (e.g. Dodd, 1995; Stackhouse and Wells, 1997, 2001; Briscoe, 2001; Bishop, 2003). Dodd's approach to this heterogeneity issue has been to consider different subgroups of children with speech disorders. Sub-grouping is determined by investigations of children's surface speech errors and linking these to a psycholinguistic perspective. In the present study each of the children was classified into one of these groups: four of the children were delayed and one was dyspraxic. Dodd has made suggestions based on her own (e.g. Dodd and Iacono, 1989; Holm and Dodd, 1999; Dodd and Bradford, 2000) and others' research (Hoffman et al., 1990) into how these sub-groups of children respond to intervention. This has been discussed in greater detail in the children's chapters, and is further summarised in the following chapter. Dodd suggests that children with delayed speech do not have a specific locus of deficit in terms of a speech processing model, but rather that the entire system is like that of a younger child. Although many of the children *did* have wide-ranging deficits, many nevertheless had relative clear areas of strength and weakness on their profiles (e.g. consider Joshua's relatively strong input skills shown in Figure 6.1). It may be more appropriate to consider children with delayed speech in terms of developmental phase models, and children with disordered speech in terms of speech processing models. Sub-grouping children may be an important initial diagnostic step, with further investigations then taking place to determine at which point on a developmental phase model (e.g. see Figure 2.4) the child has become 'stuck.' Sub-grouping and profiling approaches have great appeal to clinicians since they lead on to intervention planning – their value is further discussed in the following chapter.

4. SUMMARY OF THEORETICAL CONTRIBUTIONS

One of the main aims of this work was to demonstrate 'real theoretical significance.' Within the limitations of the study (further discussed in the following chapter) this has been achieved. Theoretical contributions derived from the five cases presented include:

- Across-item generalisation patterns provide support for theories about the way in which lexical items are stored, i.e. in phonological neighbourhoods by onset / rime, and with strong links between related linguistic units such as consonant clusters.

- Across-task generalisation showed children generalising from speech input or output intervention to spelling. In most cases this was specific to items targeted in intervention rather than being general gains in their literacy that may have occurred through classroom instruction. For some children with severe, core motor programming deficits, literacy may provide a compensatory means of accessing language, provided phonological representations are accurate.

- Input processing may be more amenable to change than the core deficits of output processing. Evidence from brain imaging studies supports this theory. The children in this study all improved more in terms of input (e.g. auditory discrimination, phonological representations) than output, irrespective of whether input or output was addressed.

- Stackhouse and Wells' (1997, 2001) speech processing model adequately accounted for the five clinical cases presented. Consideration of the children's difficulties and their responses to intervention supports the model which must necessarily account for all children's speech processing. More specifically, support was found for two linked phonological lexicons (phonological representations and motor programmes); strong links between phonological processing and orthographic representations; distinct processing paths for auditory discrimination of real and non words, and distinct levels of processing for motor programming and motor planning.

- Motor programming can take place at three different developmental levels: whole word mapping in the younger child conceptualised as a direct mapping from phonological representations to motor programmes, phonotactic mapping, and phonemic mapping. These developmental levels of motor programming can be included on Stackhouse and Wells' (1997) model in order to expand our knowledge of this underspecified level of processing, and so that the model more explicitly incorporates a developmental perspective.

- Models such as Stackhouse and Wells' (1997, 2001) need to be developed to enable us to better understand the way in which grammatical processing and connected speech interface.

- Developmental phase models provide a useful way of understanding children's speech processing difficulties. These models yield a longitudinal perspective of development in contrast to information processing models that offer a 'snap shot' view of development at a particular moment in time. The approaches are not mutually exclusive and an attempt was made to combine the two in this chapter. Developmental phase models may be particularly useful in furthering our understanding of children sub-grouped into the 'delayed speech' sub-group.

- Motor programming difficulties may be a core deficit for many children with persisting speech difficulties.

- The concept of mapping is important to our understanding of these children, and can be viewed from a developmental perspective. Initially children need to carry out 'input' mapping (as described by Chiat, 2000, 2001) in which semantic and phonological information is linked. A second phase of mapping is hypothesised: output mapping in which the phonological/semantic representations must be mapped onto output forms. It is with this second level of mapping that many children experience difficulties.

CHAPTER 11: DISCUSSION OF CLINICAL ISSUES

Chapter Outline Page

This chapter returns to the issues introduced in Chapter 1 regarding intervention studies and their importance from a clinical perspective. The discussion here focuses on the clinical contributions made by the case studies presented in this thesis. The first section of the chapter compares and contrasts cases in terms of the contributions they make to evidence-based practice. Chapter 1 presented a review of model-based intervention studies which used a single case methodology to focus on the school-age child. It was shown (Table 1.3, Chapter 1) that there is only a small body of studies meeting these criteria. This study aimed to add to this body of work by carrying out a series of detailed, principled interventions to evaluate therapy effectiveness. The clinical contributions of the studies extend, however, beyond mere addition of volume to the evidence base: Section 1 of this chapter considers levels of the outcomes hierarchy attempting to outline, with supporting evidence, what the case studies have taught us about effectiveness, and about specificity, i.e. what therapy works for different children under different conditions? Section 2 considers Stackhouse and Wells' (1997) psycholinguistic framework as a clinical tool, evaluating the speech processing profile from this perspective, and emphasising the way in which the psycholinguistic and linguistic approaches were combined in the case studies. Section 4 returns to the strong links between therapy and theory, summarising the clinical contributions of the research and tying this in with the theoretical contributions from the previous chapter. In section 5, the study is critically evaluated, while section 6 considers suggestions for future directions arising out of this work.

1. THERAPY OUTCOMES: BUILDING THE EVIDENCE BASE

Chapter 1 introduced a hierarchical model outlining different levels of knowledge which might be addressed by intervention research (Frattali, 1998; Figure 1.1). At level one, and forming the basis of the hierarchy is the following question: Does speech and language therapy work? Results from previous studies of children with phonological difficulties suggest that for this group of children, intervention typically brings about positive change (e.g. Nye, Foster and Seaman, 1987; Shriberg and Kwiatkowski, 1994; Gierut, 1998b; Law, Boyle, Harris, Harkness and Nye, 1998; Goldstein and Geirut, 1998; Law and Garret, 2003; Joffe and Serry, 2004). However, this issue is not as clear-cut as it may seem since outcomes measures and criteria used to determine 'success' can vary widely. The first subsection (section 1.1) describes different levels of outcomes measures, in particular discussing the wide-ranging measures employed in the case-series. Level 2 of Frattali's (1998) outcomes hierarchy is concerned with the issue of specificity, focussing on how child characteristics and the nature of intervention affect outcomes. Questions at this level of the hierarchy have mostly been addressed in studies of efficiency. Efficiency studies were reviewed in Chapter 1 where it was shown that 'intra-intervention studies' are concerned with making therapy better, by considering target selection issues. Inter-intervention studies compare two (or more) different approaches to intervention. There is a great need for further research addressing this level of the intervention hierarchy. The present study aimed to address some of the issues associated with this level. Generalisation and target selection are considered from a clinical perspective in section 1.2, while section 1.3 considers the increasingly pressing issues of cost-effectiveness and dosage. Section 1.4 considers diagnostic sub-groups of children with speech disorders, considering how the present intervention case studies contribute to the body of work already carried out in this area, and how individual characteristics of the five children add to our knowledge about therapy outcomes.

1.1 A range of outcomes measures

A wide range of outcomes measures was employed for each of the five case studies described in this thesis. It was argued that outcomes measures which range comprehensively from the very specific (i.e. the micro measures of this study) to the more general (i.e. the macro measures used for each of the children) seem most likely to yield a complete picture of the type of change occurring for each child as a result of intervention. While it has been argued that outcomes measures need to be socially and functionally relevant to children's lives (Lees and Urwin, 1997), they should also be sufficiently sensitive to measure small changes in the underlying processing system. At a macro level, standardised tests can be useful but in isolation these provide a gross measure of change. This has been emphasised by other authors (e.g. Ebbels, 2000; Crosbie, Dodd and Howard, 2002), but remains a fairly widespread approach to evaluating effectiveness of therapy both in clinical and research settings.

Improving intelligibility is an important aim for many interventions so that children are able to make themselves better understood to unfamiliar listeners (Flipsen, 1995; Dodd and Bradford, 2000). Clearly, this is an ambitious aim for children with severe and persisting problems that may take many years of intervention to achieve. Gains in literacy and underlying processing skills are also important for these children. If one relied only on macro measures, one might erroneously conclude that no progress had been made. Using micro measures allows one to provide a more complete picture of the change that occurred. From this point of view, intervention is considered successful if any significant change has been brought about on appropriately selected and measured stimuli. These micro and macro levels are similar to the outcomes measures described by Frattali (1998), and also employed by Bunning (2004) to a range of different intervention settings. These authors refer to intermediate, instrumental and ultimate outcomes. Intermediate outcomes are analogous to the micro measures employed in this study: they measure change relative to the child's own performance. Instrumental outcomes are described as outcomes which indicate whether to continue or close an episode of intervention. It is noted that once an individual has achieved an instrumental outcome "it is assumed that progress will continue beyond the intervention episode." (Bunning, 2004, p.105). Ultimate outcomes are analogous to macro measures employed in the case studies: they relate to functional communication (e.g. intelligibility) and the child's performance in relation to their peers. These terms were not employed in the present study mainly because of difficulties in defining instrumental outcomes: these may frequently overlap with the other two categories, depending on the nature and severity of the child's difficulties. Roulstone (2001) distinguishes between primary and secondary outcomes, with the former relating to aspects of the individual's behaviour and the latter reflecting the behaviour or opinions of others (e.g. intelligibility as judged by unfamiliar listeners, parent and teacher report). A consensus from these authors is that a range of outcomes measures should be employed in routine intervention.

Each of the intervention programmes described here was successful in that the children's production of specific stimuli items addressed in the therapy, improved. However, the extent of the generalisation at a micro level, and the extent of micro gains through to macro gains varied widely. Figure 11.1 provides an overview of the levels of change that occurred for each of the children participating in the study.

Figure 11.1
Indices of change for each of the child participants

Significant changes in:	Oliver	Katie	Joshua	Rachel	Ben	
intelligibility		(√)*		√	√	MACRO
standardised tests				√		
speech processing profile		√	√	√		---
generalisation to untreated stimuli	√	√	√	√	√	MICRO
treated stimuli	√	√	√	√	√	

* Significant change in severity indices (PCC, PPC) not intelligibility.

All five children made gains at the micro level, although the extent of the generalisation occurring to untreated items varied widely, as outlined in each child's chapter. Rachel was the child with most wide-ranging positive change and this extended to her intelligibility at a macro level. Intelligibility increases as a result of fairly major or widespread change, not just as a result of improvement in one part of the speech processing system, and this is an important factor to bear in mind when using it as an outcomes measure. Oliver, in contrast, did not show significant change at the macro level with all his change occurring at the micro level. This child evidenced speech difficulties typical of developmental verbal dyspraxia, and his limited response to intervention is fairly typical of that condition (Shriberg et al., 1997a, b). There is a very small body of research regarding treatment outcomes for children with DVD (e.g. Helfrich-Miller, 1994; Velleman, 1994; Rosenthal, 1994; Bornman et al., 2001. It may be that the limited (or very slow) success arising from intervention with these children, has limited the publishing of such intervention cases. Oliver's case (described in Chapter 4) contributes to the evidence base for treatment of children with dyspraxia. Significant change was demonstrated in Oliver's speech production (as well as in three other speech processing areas) at a micro level, i.e. for the targeted stimuli words as well as matched control lists of words. These findings suggest that while children with DVD may make slow progress, intervention can be effective in bringing about change to a wide range of speech processing skills. Joffe and Reilly (2004) review the evidence base for treatment of motor speech disorders such as developmental verbal dyspraxia and dysarthria. Based on the extremely limited body of evidence available, they conclude that:

> "the evidence for improving speech intelligibility outcomes in children with motor speech disorders is weak." (p.247)

This could be related (a) to the limited amount of work measuring changes in children's intelligibility, and (b) the fact that intelligibility is a broad major of change and should not be the only outcome when working with children with these types of difficulties: changes in literacy, auditory discrimination and self-esteem are all important. More intervention studies of children with motor speech disorders are needed. Such studies should employ a range of outcomes measures so that success may be demonstrated at least at some level. Long-term intervention studies of such children may yield a more complete picture of the outcomes of intervention over time: is there a point at which macro changes are noted, and what is the intervention dosage required to reach this level? Like Oliver, Joshua showed mainly micro gains with macro changes limited to a few changes on his speech processing profile and not extending to intelligibility or standardised tests.

Ben and Katie's pattern of change was slightly different to that of the other children, suggesting that the hierarchical ordering of assessments may not be appropriate. Ben made changes at the micro level, but revealed no difference in his speech processing profile or at the level of standardised tests. However, his intelligibility had improved significantly as outlined in Chapter 9. The intelligibility evaluation in this study involved comparison of each child's intelligibility before and after intervention. Each child acted as their own control and comparisons were not made with normative data for other children, since this was not readily available. In contrast, the standardised tests (and tests used to compile the speech processing profile) involved comparison of each child's performance with that of normally developing age-matched peers. As such, the intelligibility evaluation should possibly be considered at a lower level of the macro evaluation rather than at the top of the assessment hierarchy. Katie's pattern of changes was similar to Ben's, although her intelligibility did not change significantly her speech severity did. Indices of change such as those presented in Figure 11.1 are helpful in their conceptualisation of change at a series of levels, rather than considering it in an absolute fashion.

Joffe and Serry (2004) outline the current evidence base for the treatment of articulation and phonological difficulties in children. These authors highlight several issues, similar to those raised by Sommers, Logsdon and Wright (1992) more than ten years before! They suggest that there is a great need to expand the evidence base through carefully designed interventions employing a range of outcomes measures. None of the intervention studies reviewed in Chapter 1 – or included in Joffe and Serry's (2004) review - used the same range of outcomes measures as those used in the present work. It is suggested that intervention studies focusing on small numbers of children using a single-case methodology, should employ a similar range of measures in order to provide a full picture of how intervention affects the child. This is important, not only in improving our understanding of effectiveness at level one of Frattali's (1998) outcomes hierarchy (Figure 1.1), but also in considering level two, that of specificity, discussed in section 2.

1.2 Generalisation and target selection

Target selection and ways of maximising generalisation are important issues facing clinicians. The ultimate aim of intervention is to encourage generalization throughout the speech processing system. Careful selection of targets may maximize the generalization achieved, and thus ultimately the efficiency of intervention. Bunning (2004) notes that:

> "Generalisation of therapeutic gains is not something that happens as a natural consequence of therapy ... It requires deliberate planning." (p.9)

However, as was outlined in Chapter 1, there are a great many unanswered questions regarding generalisation, and it is challenging to predict how widely a particular child will generalise new skills learnt in therapy. Joffe and Serry's (2004) review of the phonological therapy evidence base reveals that intervention studies have considered generalisation to varying degrees and have found evidence for generalisation that also varies considerably. The evidence-base needs to be expanded and developed to assist in target selection, and replications of documented intervention studies would be one way of providing a clearer picture of the generalisation.

Although generalisation cannot be predicted with certainty given the current state of the evidence base and the heterogeneity of the population, if children's target stimuli are selected carefully and with some knowledge of linguistic theory then chances for generalisation may be maximised. Generalisation is a good example of an aspect of intervention studies that is equally as important from a clinical perspective (i.e. in terms of efficiency) as from a theoretical one (i.e. in terms of how it informs our knowledge of linguistic theory and psycholinguistic processing). Since the latter has been discussed in the preceding chapter, this section centres on what has been learnt regarding efficiency of intervention and target selection. Across-item and across-task generalisation for each of the children is summarised in Table 10.1 and 10.2 in the preceding chapter. In general, these tables confirm what was noted in Chapter 1: generalisation is very variable from child to child, and stimulus to stimulus. It does not seem to occur in predictable ways. In each case study significant generalisation from treated stimuli to untreated but carefully, matched stimuli was found. In some cases this generalisation extended to novel words (e.g. Rachel and Joshua) and in other cases to words with the target phoneme in different word positions (Rachel). Unlike Rachel, the results of Oliver's intervention showed minimal generalisation from one word position to another. The literature on generalisation is also equivocal about this point: although it does seem to occur in some instances it does not always occur. Further themes regarding generalisation and target selection are discussed in the sections that follow.

1.2.1 Connected speech

An important theme of Katie's chapter was that of connected speech. Speech and language therapy typically focuses on children's production of specific speech sounds or production of single words (e.g. Forrest, Elbert and Dinnsen, 2000; Williams, 2000a,b; Barlow and Gierut, 2002). Many children are able to apply what they have learnt at a segmental or whole-word level to conversational speech, and some studies have explicitly measured this type of generalisation (e.g. Wright, Shelton and Arndt, 1969; Elbert, Dinnsen, Swartzlander and Chin, 1990; Almost and Rosenbaum, 1998). However, this is not always the case, and many therapists working with older children with persisting speech difficulties find it difficult to intervene with connected and spontaneous speech beyond the clinic room and beyond the single word level. Indeed, therapists may discharge children at this point hoping that generalisation will occur into spontaneous speech without intervention (Bunning, 2004).

There is little research addressing the relationship between connected speech and single word speech production in intervention despite the fact that connected speech has important implications from a functional point of view and in terms of intervention efficiency. The work with Katie suggested (1) that she needed specific intervention aimed at motor planning in order for generalisation of final consonant production to extend into her connected speech, and (2) that intervention might have been more efficient if this level had been immediately addressed. These findings may be specific to Katie and a small group of children with similar speech processing difficulties. However, an important theme in this thesis has been consideration of the level of linguistic unit stored at different phases of speech development. (e.g. see section 2.1.1.1 in Chapter 2). In section 1.3.1 (Chapter 10) it was suggested that many of the children's difficulties with motor programming could be accounted for in terms of a developmental phase model of motor programming which sees children moving from whole-word mapping, to phonotactic frames and ultimately mapping at a phonemic level. Oliver, Katie and Rachel provided good examples of children who seemed to be carrying out mapping at each of these developmental levels respectively. For children with motor programming difficulties it may be developmentally more appropriate to start by addressing larger chunks of speech, rather than following the traditional hierarchy of single sounds at the most basic level of motor programming.

From a clinical perspective, it would be valuable to be able to distinguish between children who (a) will be able to spontaneously generalise what they learn in therapy at a single word level into connected speech, and (b) are not going to be able to generalise in this way, and whose therapy should immediately target the level of connected speech. The intervention with Katie allows for generation of some hypotheses about making this distinction. It may be that children with very severe speech difficulties are not able to generalise automatically into connected speech, or that children beyond the critical age of 5;5 are not able to generalise single word changes into connected speech. These hypotheses will need to be tested out by means of further systematic research.

1.2.2 Developmental hierarchies in intervention

Having an understanding of developmental progression does not automatically translate into a hierarchy for target selection for intervention. Many researchers have suggested that a developmental sequence should be adhered to (e.g. Grunwell, 1985, 1987, 1990; Corrin, 2001a, b). The consideration of this factor in target selection was a theme running through many of the cases presented. In general, it was found that children seemed to respond favourably to the traditional developmental targets. Oliver's response to intervention supported the use of traditional developmental hierarchies: He made the most significant gains for sounds that are early acquired ([k] and [t]), and with the later developing sounds he made less progress. If all targets had been selected according to this developmental perspective, the gains overall may have been greater.

In Joshua's case, all consonant clusters were addressed. Joshua seemed to follow developmental trends as, by the end of intervention he had acquired all of the earliest acquired clusters, e.g. those usually mastered by 3;6 ([tw] and [kw]) and those that children typically begin to acquire at 4;0 (e.g. [pl], [bl]) and 5;0 (e.g. [tr], [dr]). The s-clusters, including the three-element clusters, remained challenging for Joshua. Three-element clusters are typically some of the last elements of phonemic acquisition (Mcleod, van Doorn and Reed, 1997). In general, it seems that intervention was able to expedite normal phonological development, although the [s] clusters seemed not to fit in with this pattern, functioning as a separate group and somewhat resistant to change.

Ben had four consonants targeted in intervention. Only [θ] and [tʃ] contributed to the overall change over the programme. [ʃ] was the phoneme that made the most limited gains. Developmental hierarchies were not adhered to since [θ] is a phoneme typically acquired approximately one year later (at an average CA of 6;0, Smit et al., 1990) than the phonemes [ʃ] and [tʃ] and the cluster [st]. In Ben's chapter (chapter 8) the point is made that his intervention may have needed to be more differentiated in terms of the specific treatment given to individual phonemes, and this may have affected the results, i.e. all the four targets were not appropriately addressed in intervention and it would be misleading to base an evaluation of stimuli selection on these results.

1.2.3 Productive phonological knowledge (PPK) in intervention

Authors such as Gierut (1992, 1998b) and Gierut, Morrisette, Hughes and Rowland (1996) have predicted that greater generalisation will occur when more advanced targets are selected, specifically sounds about which the child has little or no productive phonological knowledge (PPK). The consideration of this factor in target selection was a theme running through the cases presented. In general there was little support for PPK claims, although it is acknowledged that the methodologies employed in the cases may not be the most appropriate for evaluating such claims. Gierut (1992, 1998b) suggested that working on PPK Type 6 targets maximally promotes *generalisation* to other categories (i.e. it is most efficient) rather than stating that work on type 6 phonemes is *more effective*. This is an important distinction and reminds us that her claims are probably best investigated using groups of children, as has been done by authors such as Williams (1991). The patterns of change noted in the five children's cases are interesting, but since a range of sounds was addressed in each case, it is not known what patterns of generalisation might have occurred if only type 3 or type 6 items had been addressed, or if a longer period of intervention had been carried out. The results of the present work suggested that within the given timescales for intervention, greater change seemed to be brought about by working on developmental targets. However, it is difficult to come up with any firm conclusions about this issue because the methodology does not allow for direct comparison of the two approaches, and if the children had received intervention over a longer period of time then the overall efficiency of the programme might have been different to that noted in the shorter term.

Oliver's response to intervention supported the use of traditional developmental hierarchies and showed that for him PPK was not an important consideration for intervention planning. [k] and [t] differed widely in terms of PPK category with [k] considered as a type 3 phoneme, the group of sounds about which Oliver knew the most, and [t] as a type 6 phoneme, the group of sounds about which Oliver knew nothing. PPK category seemed to have little bearing on Oliver's response to intervention, despite predictions in the literature that [t] would be the best phoneme for bringing about widespread generalisation (Gierut and Dinnsen, 1987). In Ben's case four phoneme stimuli were targeted. Only two phonemes [θ] and [tʃ] contributed to the overall change over the programme. [ʃ] was the phoneme that made the least gains. One explanation is that Ben had very limited PPK of this phoneme, and it was easier for him to make gains with sounds that he had at least some knowledge about, such as [θ] and [tʃ]. Like Oliver, no support for the theories of least PPK leading to maximal change, was found.

In Joshua's case, all consonant clusters were addressed. The majority of these were in the type 6 category, phonemes about which Joshua had no phonological knowledge and never used correctly. Two of the clusters, [sk] and [st] were considered to be Type 4 'positional constraint' clusters which Joshua was able to use word finally but not initially. The remaining 6 clusters, [kl], [kw], [kr], [br], [gl] and [tw] were clusters from type 3, about which Joshua had the most phonological knowledge. He was able to produce these correctly on occasion but had frozen forms for some specific words. The type 6 clusters varied widely in the pattern of changes observed: some were efficiently modified (e.g. [tr]) while others showed no change (e.g. [sp]). Each of the 3-part clusters (e.g., [spl] and [spr]) made very limited change. The two clusters classed as Type 4 also made very limited change, suggesting that although Joshua initially had more phonological knowledge of these sounds, this did not aid the remediation process (see Table 6.19 for a summary of Joshua's progress). Many of the [s] clusters were problematic for Joshua to acquire and this is something that has been noted in the literature (e.g. Barlow, 2001). Six clusters were classed as type 3 clusters – sounds about which Joshua knew the most. No [s] clusters were included in this set. Joshua made excellent progress with each of these clusters (e.g. see [tw], [kw] and [br] in Table 6.13) suggesting, in contrast to the other children, that having some knowledge *is* a good prognostic factor for intervention.

Considering her varying baselines at the start of the study, it seems likely that Rachel's PPK of [st] was higher than for the other two clusters addressed in her intervention programme. The generalisation pattern observed in this study supports the theory: Rachel improved not only in her ability to produce the [s] clusters but also in her ability to produce singleton [s] and other fricatives, most notably [z]. However, it should be cautioned that Rachel was becoming increasingly proficient in her singleton [s] production during the initial assessment, and she may have been ready to acquire that phoneme in any event. It is also interesting to note that contrary to the predictions of Gierut et al. (1987), Rachel's speech production of three-part consonant clusters also improved. Detractors of Gierut et al.'s (1987) complexity accounts of treatment efficacy (e.g. Williams, 1991) suggest that the categories of phonological knowledge may be too broad to characterise the precise level of knowledge, and further that in real-life settings complex targets are often not suitable treatment goals since children find them too challenging in the initial stages of therapy. From Rachel's intervention one might conclude that choosing moderately challenging targets is a successful compromise with the child not being outfaced and generalisation occurring both downwards to the less complex structures and upwards to the more complex aspects.

1.2.4 Consonant clusters in intervention

Accurate realisations of consonant clusters typically emerge in children's speech between the ages of 3;6 to 8;0 (Mcleod et al., 2001). For most normally-developing children they emerge with no specific intervention, and gradually come to be produced in adult-like ways. However, for some children consonant clusters pose particular difficulties and they are sounds that speech and language therapists frequently find themselves working on in clinical settings. Gierut (1999) has described consonant clusters as being very vulnerable in the course of acquisition. Rachel and Joshua were children whose intervention focussed specifically on clusters. All Joshua's word initial consonant clusters were addressed, while word final clusters [sp], [st] and [sk] formed the focus of Rachel's intervention programme.

The pattern of change observed in Joshua's clusters provided support for the notion that s-clusters are different to other clusters and respond differently to intervention than other clusters (Barlow, 2001; Velleman, 2002). The special status of [s] clusters has been supported by other treatment studies which have found that treatment of these adjuncts does not result in generalisation to other clusters (Gierut, 1999). Furthermore, it has been noted that the adjuncts as a group may be acquired before other clusters, or after – but essentially that they can be clearly distinguished as a group from the other clusters. [s] clusters certainly seemed most challenging for Joshua, but this may be because he had difficulties in *articulating* [s] at the start of the intervention. Gierut (1999) found that treatment of [s] + stop clusters did not promote widespread change across all consonant sequences, while treatment of other consonant sequences did (Gierut, 1999). Rachel's intervention of word final [s] + stop clusters resulted in generalisation to other more complex, three-element [s] clusters as well as to singleton [s] and other fricatives.

Mcleod et al. (1997) have reported that there is no clear developmental hierarchy for the development of [s] clusters word initially or finally, although it is known that [s] production may be easier for children acquiring this phoneme in word final position (Grunwell, 1985; Redford, MacNeilage and Davis, 1997). In Rachel's case extensive generalisation was found across word position with Rachel able to apply her knowledge of the word-final consonant clusters to the same clusters in other positions, something which Joshua was not able to do. In terms of the specific [s]+ stop clusters, there is some evidence that [sk] may be slightly later acquired on average, when compared to [sp] and [st]. This finding did not apply to Rachel. However, it was observed that [st] was more advanced in both her speech and spelling than the other two clusters. Although this is not reported in any of the cluster studies, [st] does occur more frequently in word-final position than the other two clusters which may be a factor in its early emergence.

There are other effects of intervention that are hard to disentangle for both children: The aim of applying three different treatments to three cluster sets, in Rachel's case, was to monitor the progress observed for each set, almost as if three different children were receiving three different treatments. Results of the study suggested that each treatment affected the speech processing system as a whole and effects could not be separated from word-list to word-list. In Joshua's case, a multiple baseline design was used with different clusters being treated at different phases of intervention. In the early phases of intervention there was a clear effect of intervention on the particular clusters targeted in that phase, but by the third phase of intervention this pattern was not clear, with clusters from that set improving prior to the specific treatment targeted at them. This finding is not entirely surprising (Seron, 1997), and suggests that the *concept* of a cluster might have been the most important aspect of intervention. A small set of exemplars might have been sufficient in bringing about change rather than attempting to include all clusters. The questions of 'how many exemplars to use?' and 'which exemplars to use?' are important ones. While some authors have suggested that the answer to the first question is just one feature contrast (Blache, Parsons and Humphreys, 1981) or one phoneme (Gierut et al. 1987), others such as Edwards (1983) and Hodson and Paden (1991) have suggested multiple exemplars are preferable. A phonotactic approach to therapy (e.g. as advocated by Velleman, 2002) accords well with this point of view. Velleman suggests that focusing on the concept of a new word shape (e.g. CCVC) may well result in generalisation beyond the treated sounds. These are useful findings in that therapists can consider [s] clusters, such as the ones targeted in these studies, as being very closely linked with overlap in the way they are stored in children's speech processing system.

1.3 Cost-effectiveness and dosage

Intervention dosage is an important issue about which relatively little is known. In this study the intervention given was relatively intensive in terms of what the children had been receiving prior to their participation in the project, and on completion of the project. However, the intervention was not as intensive as that given for example by Tallal et al. (1993, 1996) in their intervention studies using computerised auditory training. The intervention carried out for the children might have had different results if the dosage was greater and children were seen daily for a shorter time period rather than twice weekly over the space of many months. There is a great deal of research still to be done regarding the 'shape' of intervention and the type of dosage that is optimum for children with different types and severity of speech problems.

The intervention aimed to be realistic – the type of dosage that might feasibly be given by private practitioners or therapists employed by the local health service[26] – and fitting in with the children's schooling. What can be stated with certainty is that the children made significant gains over the course of intervention, and made more progress than they had previously made with a far more limited dosage. Rachel was discharged on completion of her intervention, but the other children remained in need of regular and intensive intervention. The relatively high dosage of intervention given was not sufficient to address all their difficulties. This raises the issues of intervention effects versus service delivery evaluation, as raised in Chapter 2. Law and Conti-Ramsden (2000) emphasise this issue in their evaluation of routine NHS speech and language treatment effectiveness, albeit for younger children.

> "Offering limited amounts of speech and language therapy is not a tenable solution to the problem. The six hours provided did not necessarily reflect the choice of the speech and language therapists in the study but rather a constraint imposed on them by the ... model of service delivery... Such a simplistic model is not helpful... Practitioners ... should be able to offer a more flexible package of interventions. This is likely to require a reorganisation of ...services, but this is the point of practising evidence-based medicine: when you fill the evidence gap you need to act. (Law and Conti-Ramsden, 2002, p.909-910)

Health service managers are under great pressure to justify the services they deliver not only in terms of positive outcomes, but also in terms of cost-effectiveness. For a child with severe speech difficulties achieving basic communicative independence will typically require intensive and ongoing speech therapy (Hall, Jordan and Robin, 1993). As health care costs continue to rise, it will become even more important to justify frequent speech therapy

[26] Although this may be debatable in the case of the latter, based on reports such as Law et al. (2002).

sessions over a long period of time. Cost-effectiveness, cost-benefit, and cost-utility are terms used to link the expenses associated with providing intervention to the outcomes obtained as a result of that intervention. Cost-effectiveness links the monetary cost of an intervention to improvement of direct health / educational outcomes, e.g. the cost of an intervention compared to the cost savings of preventing additional expenses (e.g., admission to a special school, need for counseling or psycho-therapy). Cost-benefit compares the monetary cost of the intervention with the monetary benefit of the outcome measured more broadly in terms of increased income and improved leisure time. Cost-utility compares the monetary cost of the treatment most broadly with quality of life outcome. Some interventions may not be justifiable in terms of cost-effectiveness, but may be argued for in terms of cost-utility (Golper, 2001). Sackett, Richardson, Rosenberg and Haynes (1997) observe that:

> "Some fear that evidence-based medicine will be highjacked by purchasers and managers to cut the cost of health care. This would not only be a misuse of evidence-based medicine but suggests a fundamental misunderstanding of its financial consequences" (p. 4).

Certainly, clinicians subscribing to evidence-based practice should identify and provide the most efficacious treatments to maximize their client's quality, and if applicable, quantity, of life. Ultimately, this may raise rather than lower the cost of care. Robey and Schultz's (1998) five-phase outcome research model provides a systematic method for developing a treatment: (1) developing hypotheses about the treatment, (2) evaluating effectiveness, (3) testing the intervention's efficacy; (4) examining its efficiency; and (5) determining its cost-effectiveness, cost-benefit, and cost-utility. Specific research designs are appropriate for each phase in the model, and the evidence about a treatment's outcome, as tested in each phase, can be rated by a 'level of evidence' scale. Progression through the phases must occur in a sequential way with each phase building on the findings from the previous one. The first phase is about 'discovery,' developing hypotheses about intervention to be tested in later phases. Single subject designs are appropriate at this level. If this phase reveals that no harm is caused and the effects of intervention are positive, it is appropriate to proceed to the next phase. In phase II single subject designs remain appropriate, but are used to more systematically investigate effectiveness: what is the ideal that an intervention might strive for? Once this question has been answered, phase III investigations can occur. In phase III efficacy is evaluated, under ideal conditions, and typically employing more powerful designs such as randomised control trials. If the efficacy of the intervention is established in phase III, it is appropriate to move on to phase IV where an intervention shown to be positive in the previous phase, is now evaluated under average conditions. In the final phase, if the treatment has been shown to be successful under average conditions, investigations then take place into its cost-effectiveness, cost-benefit and cost-utility. Thus, it is suggested that while cost-effectiveness may be at the forefront of managers' and purchasers' minds, it is the researcher's role to move through the five outcomes phases, concerned with building a solid foundation of evidence for a particular intervention and considering cost-effectiveness at the appropriate point once a fairly substantial amount of outcomes data has been amassed. The present work was carried out in line with Robey and Schultz's Phases I and II.

School-age children may be particularly vulnerable to the effects of cost-cutting and rationalisation: many health authorities consider early intervention to be a greater priority than intervention for the school-age child. Increasingly consultative models are being adopted in schools with speech and language therapists having limited opportunity for providing one-to-one intervention for children. Therapy programmes are often carried out by classroom assistants and other members of the teaching staff (Law et al., 2002). While such approaches can be appropriate for some children it may not be appropriate for children with severe and persisting difficulties that have not responded to previous intervention. The interventions described in this thesis have shown that work with such children requires lengthy assessment and ongoing consideration and re-evaluation of their difficulties, something which untrained personnel would not be able to do.

Despite the need for school-age children with persisting difficulties to access intensive intervention, it is difficult to justify enormous amounts of time and effort spent on just a few children (Law et al., 2002). It is estimated that 14.3 speech and language therapists work with children in any given health trust in the United Kingdom and the average ratio of SLT to child population is estimated at 1:4257. Recent prevalence data suggests that 7.4% of school-age children have speech and language difficulties (Tomblin et al., 1997). This equates to a typical caseload of 315 children per therapist. Law et al. (2002) have suggested that 40 children is a more desirable level for a notional caseload (Law et al., 2002). There is obviously a considerable difference and a clearly discrepancy here. A consultancy model with limited therapist-child contact, and intervention that is less tailor-made to an individual child's needs offers a way of coping with these large numbers. However, it is suggested that it remains for researchers and others who are able to carry out intervention beyond the confines of a particular service delivery model (e.g. independent practitioners) to investigate more intensive, tailor-made interventions. Collecting and providing data from this type of intervention will be a valuable addition to the evidence-base, and may ultimately allow for a justification of tailor-made, intensive, one-to-one interventions for those children who need it (Zeit and Johnson, 2002). There is a growing body of evidence suggesting that in order to bring about long-term changes in speech and language, intensive input and carefully targeted intervention is needed (Law et al., 1998;

Tallal, 2000; Glogowska, Campbell, Peters, Roulstone and Enderby, 2002). The five cases presented in this thesis contribute to that body of evidence.

Not only is data that proves the effectiveness of speech and language therapy services lacking, but few studies have addressed the issue of how much intervention is typically needed to bring about progress (Jacoby, Lee, Kummer, Levin, Creaghead, 2002). ASHA developed the National Outcomes Measurement System (NOMS) for the purpose of tracking functional gains in individuals receiving therapy. NOMS data revealed that after 17 hours of treatment, 16.4% of 3-6 year old children with a severe articulation disorder moved to a functional level for discharge. However the large majority of children (83.6%), did not evidence significant change and required additional treatment. This information shows that short-term intervention can benefit a small percentage of children, but that most children with severe speech and language disorders require more treatment time to achieve a functional communication level that enables them to participate in age-appropriate activities (Zeit and Johnson, 2002). The children in the present study received from 10 hours (Rachel) to 36 hours (Ben) of intervention with an average dosage of 25 hours per child. Apart from Rachel whose specific difficulties were addressed after 10 hours of intervention, the other children all required further intervention.

1.4 Diagnostic sub-groups and individual children

Dodd's (1995) diagnostic subgroups have been discussed in some detail in preceding chapters. Each child was classified according to their profile of speech difficulties into the appropriate subgroup. Four of the children were found to have delayed speech, and one child, Oliver, showed speech difficulties consistent with developmental verbal dyspraxia. Holm and Dodd (2000) suggest that children with phonological delays benefit from a 'whole language approach.' Hoffman, Norris, and Monjure (1990) carried out narrative-based discourse therapy with a single, pre-school child, aiming to tap into a variety of levels of language, i.e. semantics, syntax, and phonology. The outcome of the intervention was positive with the child making significant gains in each of these areas after six weeks of intervention. The results were accounted for in terms of a synergistic relationship between the different components of language. This approach of working on higher level language functions without specifically addressing phonology, seemed promising as an efficient means of remediation. However, subsequent studies (e.g. Tyler and Watterson, 1991; Fey, Cleave, Ravida, Long, Dejmal and Easton, 1994) using similar 'whole language' treatments did not find the same results, with results possibly confounded by age differences between the children. These studies found that whole language treatments affected syntax, but that phonological difficulties needed to be directly addressed if gains were to be made in this area. Law and Garret's (2003) systematic review supported the idea that phonological therapies are typically successful in addressing speech problems, and that there is less evidence of effective outcomes from more general language approaches, both in terms of their effect on language and on speech. In the present study, the four children with delayed speech did not receive whole-language treatments. Joshua's intervention was fairly broad-based in its use of social stories to contextualise cluster words, but did not meet criteria for true whole-language therapy. Each of the four children made gains in their speech following intervention, but due to the design of the study it is not known if they would have made greater gains if a whole-language approach was applied. Given the specific nature of the children's difficulties and the fact that they had all had fairly broad-based language work in the past, it seems as if this may not have been the case.

There may be a point at which these delayed children, have delays so great and are beyond the critical age, that they cease to respond to intervention like the children described by Holm and Dodd (1990) and Hoffman et al. (1990). Rachel's difficulties were less severe than the other children, and she did respond very positively to intervention. The other 'delayed' children, Katie, Joshua and Ben are similar to the children described by Ruscello (1995) and Dagenais (1995): children with persisting core difficulties that are resistant to intervention.

Psycholinguistic approaches have developed partly in response to dissatisfaction with traditional medical diagnostic categories. The traditional approach to the classification of speech and language disorders does not focus on each person as an individual with a unique deficit in his or her processing system. The focus is on grouping people with broadly similar aetiologies or symptoms, by implication suggesting that the same treatment might be applicable to all members of the group. However, studies have shown that children with superficially similar speech difficulties may have very different patterns of underlying processing deficit (e.g. Snowling, Stackhouse and Rack, 1986; Ruscello, 1995; Chiat, 2000; Dodd and Bradford, 2000; Nathan et al., in press). Indeed the five children presented in this work provide an example of just how different children given the same medical diagnosis can be. Rachel and Oliver had both been labeled as having developmental verbal dyspraxia. The nature and degree of their difficulties varied widely, as did the underlying difficulties revealed through the speech profiling. Katie has been given a medical diagnosis of ataxic cerebral palsy. This diagnosis did not inform her intervention, since speech profiling revealed difficulties not necessarily associated with the condition, and which would almost certainly have differed from another child given the same diagnosis. Joshua was diagnosed as having DAMP (see Chapter 6, section 1.1). This diagnosis had implications for his auditory processing and behaviour, but in isolation could not provide any detail of his speech processing difficulties or of the type of speech intervention that might be suitable for him. The psycholinguistic approach is concerned with investigating underlying processing skills, so that intervention can be specifically targeted at an individual's specific point of breakdown, and carried out with an awareness of the strengths and weaknesses that underlie the individual's speech processing system. Section 3.4 of the previous chapter has outlined ways in which sub-grouping approaches can be linked with profiling approaches: the two are complementary, deriving from the same rationale that this is not a homogenous group and that intervention has to be specifically targeted if it is to be effective.

In terms of the individual children, it is difficult to pinpoint factors which might be linked to the relative success of the programme: the children differed widely in terms of age, severity of difficulties, associated language and literacy difficulties and intervention dosage. Ben, the oldest participant made the least progress, but the youngest child, Oliver, similarly made fairly circumscribed gains. Rachel had very specific, minor difficulties and made the most improvement overall. However, initially when considering her profile she was judged to be most similar to Ben, who also had fairly specific residual problems. An important distinguishing feature between these two children is their literacy skills: Rachel had age-appropriate reading and spelling in contrast to Ben who had delays in this area. Based on this limited data, one might conclude that age-appropriate literacy skills are a positive predictor of speech therapy outcome. The implications of this are (a) that children may be compensating through literacy which draws on other skills (e.g. visual processing); (b) that children have less pervasive speech/language processing problems if literacy is age-appropriate, or (c) that there is a link between IQ and literacy achievement but no correlation between speech severity and IQ.

In terms of degree of severity, there is again no clear prognostic pattern: Oliver and Katie were the children whose speech was most severely affected. These children responded to intervention by making more positive changes than Ben, who was considerably less severely affected in terms of his speech. Cognitive factors also revealed no clear pattern: non-verbal IQ measures were discussed in the previous chapter and shown to have little effect on the intervention success.

2. AN INTEGRATED PERSPECTIVE: PSYCHOLINGUISTIC AND LINGUISTIC APPROACHES TOGETHER

Intervention approaches for children with speech difficulties typically start with a sampling of the child's speech and detailed analysis of surface speech productions. Chapter 1 (section 2.2) provided a review of phonological therapy approaches, and Joffe and Serry (2004) provide a similar longitudinal perspective of the area. These authors, in describing the shift from articulation to phonology therapy in the 1970's, suggest that discarding articulation frameworks "had the unfortunate consequence of throwing the baby out with the bath water." (p.259). Psycholinguistic approaches have become increasingly well-established in the assessment and remediation of children and adults with speech and language difficulties. They are valuable in the way in which they can inform the process of phonological therapy, but it is important to consider that phonological therapy is taking place within a psycholinguistic framework, i.e. linguistically-based phonological therapy should not be discarded in favour of a psycholinguistic approach. The two approaches are complementary, each providing different and valuable information.

Psycholinguistic speech and language processing models have inherent limitations, and even if further refined, it is doubtful if they could ever shape the clinical process in isolation. Many single case studies have relied mainly on linguistic theory and phonological analyses (e.g. Weiner, 1981; Monahan, 1986; Saben and Ingham, 1991; Bernhardt, 1992; Barlow, 2001) in planning and evaluating interventions, and this body of knowledge should be brought to bear alongside a psycholinguistically-oriented approach. The cases presented in this work aimed to show how a psycholinguistic approach can provide a framework in which linguistic (in this case phonological) knowledge is applied. Each case drew on knowledge from these two key areas: The psycholinguistic approach was useful in answering the question: 'How?' - How is intervention going to work, or how is change to be brought about in the individual's speech processing system? How can strengths be used to support / compensate for weaknesses? Knowledge from phonology enabled us to answer the more specific 'what?' question, i.e. what is the content of intervention, or what are the stimuli that will be used in the activities? For example, Oliver's speech analysis described a range of simplifying processes and drew on knowledge of normal phonological development, productive phonological knowledge and maximal / minimal opposition approaches to phonological intervention. This knowledge led to the selection of specific targets. The speech processing profile suggested that relatively strong input processing should be the focus of intervention, and careful consideration of the various levels of input processing led to the generation of a graded task hiererarchy into which the selected phonemes could be inserted.

There are few model-based intervention case studies that have attempted to couch phonological intervention within an explicit psycholinguistic framework. One example is Bryan and Howard's (1992) intervention for a five-year-old child with severe phonological difficulties. The child's speech processing difficulties were investigated through a series of psycholinguistically-motivated tasks and interpreted in the light of current models of speech and language processing. In addition a phonological analysis of the child's surface speech errors took place, with both sets of data used to inform intervention planning. This seminal paper emphasised many of the key aspects emphasised in this work, e.g. the need for levels of analysis which vary in terms of sensitivity, and the importance of understanding the difficulties underlying surface speech errors. Waters (2001) more explicitly emphasizes the need to integrate psycholinguistic information with phonological information in their report on intervention with a five-year-old boy with unintelligible speech. They suggest that while phonological analysis and psycholinguistic assessment are essential for a principled approach to intervention, they may not always be sufficient: children's attitudes, behaviours and preferred learning styles also need to be taken into account. In each of the cases presented, a third strand of knowledge was considered important for intervention planning: that of the child and his/her particular needs and preferences. This was a challenging aspect to incorporate in any systematic, controlled way but recent research (e.g. into children's learning styles, Stahl, 1999) suggests that this may be an important contributing area when planning therapeutic interventions.

Ebbels (2000) investigated the speech and language processing skills of a 10-year-old child with a hearing impairment. Specific points of breakdown for individual phonological contrasts were identified, with detailed input and output phonological analyses interpreted within a broader psycholinguistic framework. The results of the investigation showed that for some children there is not a single level of breakdown, but rather there may be multiple levels of difficulty with specific phonological contrasts implicated at particular levels. Each of the papers outlined approached assessment and intervention in different ways. However, they share a common concern with the nature of their participant's underlying phonological representations. Edwards, Fourakis, Beckman and Fox (1999) outline the evolution of representation-based approaches to understanding children's phonology, and suggest that characterizing children's phonological competence in terms of representations and the constraints acting on them allows for a richer conceptualisation of phonological development than traditional derivational and 'normalising' approaches. A further reason for careful investigation of underlying phonological representations and phonological processing ability is because of the close relationship between these skills and reading and spelling abilities. The association between phonological processing difficulties and reading and spelling problems has been shown in a number of single case studies (e.g. Campbell and Butterworth, 1985; Snowling et al., 1986) and experimental investigations comparing dyslexic children with normally-developing readers (e.g. Wagner and Torgeson, 1987). For school-age children with persisting speech problems, understanding of the child's underlying difficulties can have important implications for speech, language and literacy support. However, again we need to be careful not to wholly discard the more traditional linguistic approach.

Stackhouse and Wells' (1997) psycholinguistic framework was used as the basis for intervention planning in each of the cases in the present study. The psycholinguistic and developmental phase models constitute an important part of the framework, and have been discussed in some detail in the previous chapter. Stackhouse and Wells' framework has been designed not only to provide a theoretical account of what might happen when children process speech and language, but also to be used as a clinical tool allowing clinicians to adopt a theoretically-motivated approach to assessment and intervention. The speech processing profile is a clinical tool based on the models and one which was central to the assessment and intervention planning in the cases presented here. The profile aims to break down speech processing (input and output) into sub processes in an attempt to determine loci of deficits and to collate assessment results in a systematic way.

In general, the profile provided an excellent starting point for assessment and intervention of the complex cases presented. Information from a wide range of sources was organised into each child's profile. The first important point to note about the profile is one already highlighted: the profile cannot be used in isolation as the information gathered on the profile is typically regarding a child's strengths and weaknesses (i.e. impairments), but these need to be viewed in conjunction with information about their social situation and educational attainment and placement. Furthermore, the profile does not allow for inclusion of very detailed phonological information and needs to be interpreted together with a more detailed phonological analyses.

There are some other difficulties with the use of the profile from a clinical perspective. Level C of the profile asks: "Does the child have language specific representations of word structures? This is an important level of processing since children need to be able to distinguish between their first language and other languages that they might know. However, for many children, and for the children presented in this work, this block is not relevant. It might be useful to indicate on the profile that this is an optional level of processing. Furthermore, level L of the profile poses challenges. It is a vitally important link between output processing and the child's perception of his / her own production. If a child has sufficiently good self-monitoring skills to be able to accurately perceive their own production and to alter this appropriately, then this is valuable information that informs us about the nature of their speech processing system and what might be a useful intervention approach. However, it is a difficult aspect to assess, and there is as yet, no standardised way of objectively measuring this skill. Given the important nature of the skill, it would certainly be valuable to develop tests specifically targeting that level. Clearly, it would not be a simple matter to devise a test which only targets that level since production and perception would both need to be involved. However, a simple procedure might be devised in which children are instructed to name pictures and then explicitly given the opportunity to decide if what they have said is right or not. They might then be asked to see if they could try to produce the word a second time, but more accurately. Although such a test procedure would still require careful interpretation to see where the child's difficulties lie, there would be much to be gained from investigating how normally developing children self-monitor and repair their speech, and this data could be used as a starting point in understanding more about this important level L.

One of the most difficult aspects of intervention planning was mapping the information that had been gathered on the speech processing profile onto the information processing model. This was not always a simple case of one-to-one mapping between the two since there is not a one-to-one correspondence between the processing levels outlined in each. For example, the information processing model includes a block for 'semantic knowledge' but this aspect is not specifically tapped in the profile. Similarly, the information processing model includes a block for 'phonological representation' but the profile expands this into two levels: Level E which asks "Are the child's phonological representations accurate?" and level F which questions: "Is the child aware of the internal structure of phonological representations?" From one perspective, the profile might be considered more comprehensive if it included blocks posing specific questions about semantic processing, syntactic processing and reading and writing skills. However, the tool has been designed specifically to evaluate speech processing, and the authors have suggested that there are other tools which evaluate aspects of language such as semantics and syntax, and that the profiling approach may not lend itself as well to these aspects. These aspects of language must be included on a comprehensive theoretical model of speech processing since they are integral to it, but the clinical tool needs to be more specific in its focus if it is to be useful.

Reading and writing might be investigated more comprehensively by means of the psycholinguistic profiling approach. The speech processing profile is not strictly limited to speech in that tasks involving literacy can often be used in tapping into the different levels of the profile. However, it is suggested that a second profile might be developed which specifically focuses on literacy: the input side of the profile being concerned with reading and the output side with writing. Clearly there would be overlap with the speech processing profile, but it is suggested that having an optional second profile for use with older children and those with written language difficulties would be helpful to clinicians in systematically investigating these aspects and relating them to each other. A draft suggestion for the written language profile is presented in Figure 11.2.

Figure 11.2.
Draft version of written language profile (based on Stackhouse and Wells, 1997)

INPUT (reading)

F Is the child aware of the internal structure of phonological representations

E Are the child's phonological representations accurate?

D Can the child decode familiar words?

C Does the child have language specific representations of word structures?

B Can the child decode written forms without reference to lexical representations?

A Does the child have adequate visual perception?

OUTPUT (spelling)

G Can the child access accurate motor programmes?

H Can the child manipulate phonological units?

I Can the child write real words accurately?

J Can the child write non-words?

K Does the child have adequate hand-eye co-ordination and motor skills for hand writing?

L Does the child reject his[her own erroneous forms?

An important contribution of the psycholinguistic framework is the way in which it allows clinicians and researchers to describe assessment and intervention tasks in a systematic and detailed way. The framework forces one to be explicit about what exactly the hypothesised difficulties are and what exactly one is tapping in intervention and assessment. The importance of this structured and shared framework should not be underestimated, since there are many difficulties in evaluating and comparing effectiveness studies (as outlined in Chapter 1) because of the limited way in which intervention is often described (e.g. by using terms such as 'traditional therapy' and 'phonological awareness therapy') and the conflicting terms that can be used to describe a child's surface speech errors.

There is now a relatively substantial body of intervention work which has been carried out using psycholinguistic frameworks such as Stackhouse and Wells' (1997) and Dodd and McCormack's (1995). It is suggested that such data be pooled into a database, readily accessible to researchers and clinicians. This database would fulfil several important purposes including: (a) offering clinicians suggestions of possible treatment strategies that have worked with particular children under particular conditions (i.e. evidence-based practice); (b) encouraging clinicians to carry out intervention using methods exemplified in the database, to further extend the database; (c) allow researchers to mine the data for possible trends and hypotheses to be explored in further research.

3. AN INTEGRATED PERSPECTIVE: THEORY AND THERAPY TOGETHER

As for the opening chapters of the thesis, this chapter and the preceding one attempt to separate out the domains of theory and therapy. One of the aims of the thesis has been to show the overlapping nature of the two: theory must inform therapy, but so too can therapy inform theory. This section attempts to bring the two aspects together.

3.1 Theory and therapy

Intervention planning is a complex process: when therapists are faced with children with a range of surface speech errors and underlying processing deficits, it may be difficult to know where to begin and how to structure intervention. Oliver's intervention planning highlighted this since there was a range of potential processing areas and phonological units that might have been addressed. The psycholinguistic framework, combined with knowledge of linguistic theory, can help to make the process more transparent and explicit. If intervention is carefully targeted at an individual's specific point of breakdown, and carried out with an awareness of the strengths and weaknesses that underlie the individual's speech processing system, then it seems more likely that (a) intervention will be successful in bringing about change in the speech processing system, and (b) if intervention is *not* successful then it is possible to isolate the level of the speech processing system that therapy tasks were tapping, and make appropriate revisions. In Ben's case, generalization was minimal and the progress made for some of the targeted phonemes was not significant. Much of the discussion in Chapter 8 focused on ways in which these phonemes might be more appropriately addressed. Chapter 9 focused on intelligibility outlining numerous difficulties associated with defining, measuring and explaining this phenomenon. The potential for understanding this concept using the psycholinguistic framework was outlined.

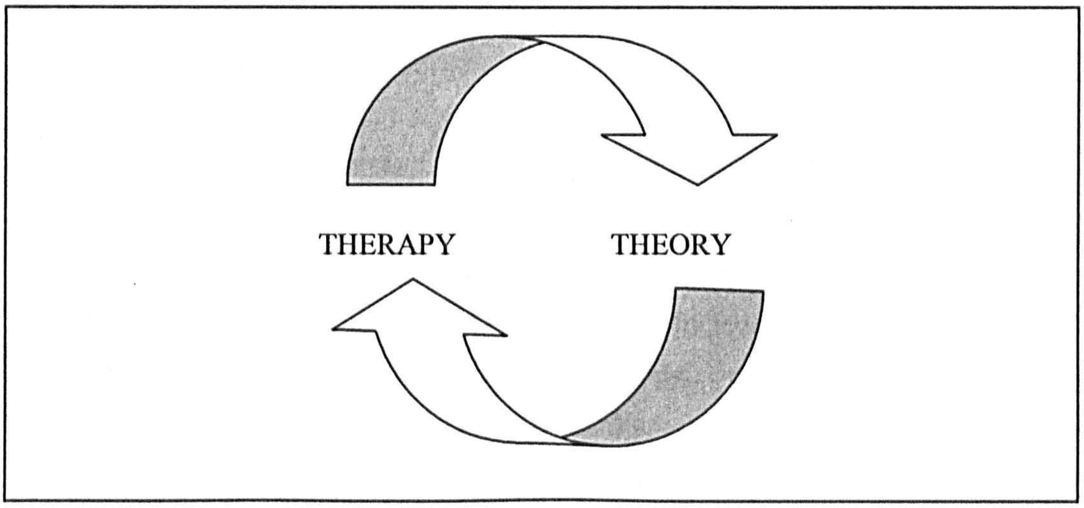
Consideration of the changes brought about by intervention for each of the children informed our knowledge of theory. Consideration of the generalization patterns for each of the children fitted in with models such as Stackhouse and Wells' (1997), and with other linguistic theories cited in Chapter 2. Contrasting the different responses of the children to intervention allowed for hypotheses to be generated regarding, for example, developmental phases of motor-programming and how these might be incorporated into the speech processing model.

Reilly (2004) describes the theory-practice gap:

> "Often, tensions exist between clinicians who fear that research will become the sole driver of clinical practice and academics who value basic science over clinically relevant research." (p.12).

One of the contributions of this work has been to show that both views are important and can be knitted together. Figure 11.3 outlines the cyclic, symbiotic relationship between theory and therapy (based on Reilly, 2004). Aspects such as generalisation have been shown in each chapter to be key to evaluations of efficiency as well as for the way in which it informs our theoretical knowledge.

Figure 11.3
The cyclical and symbiotic relationship relationship between theory and therapy (based on Reilly, 2004 p.12)



3.2 Towards a theory of therapy

Many therapists are reticent to discuss the content of their therapy. A likely reason for this is the perceived mismatch between theory and practice: theoretically-motivated work from a variety of viewpoints has provided detailed analyses of the deficits underlying some difficulties. Compared with these sophisticated analyses, many therapists' treatment techniques used in day-to-day practice appear very simple; therapists do not feel that they do justice to the complexity of the problem. Howard and Hatfield (1987) relate this to the fact that there is no 'metatheory' available which explicitly relates a deficit analysis to the process of treatment. What is a metatheory? What should it contain? And how close are we to devising one?

A metatheory or 'theory of therapy' is an account of intervention that involves systematically relating an analysis of the client's strengths and weaknesses to the process of treatment. The development of a metatheory is a pre-requisite for the development of specific and motivated therapy methods with decisions taken at each step being conscious and explicit. Only if we know exactly how a particular treatment task is meant to affect what ability and why it does so, can therapy progress. The results of intervention can support or refute hypothetical answers to these questions; but until these hypotheses are put to empirical test, we will have no means to improve our treatments. Stackhouse and Wells' (1997) psycholinguistic framework certainly goes some way towards providing a theory of therapy. Therapists adopting this approach may be carrying out games and activities which seem simple on the surface. Yet, if they are carried out with an awareness of the parts of the child's speech processing system that are being tapped, and why this is important in terms of their overall profile, then there is no mismatch between theory and therapy. Nevertheless there is further work to be done in developing a theory of therapy using this approach, e.g. what are the mechanisms for bringing about change, and how does the interaction between therapist and child affect therapy outcomes? Horton and Byng's (2000) ATICS is a system used to examine interactional aspects in adult treatment which might have application to children, and Gardner (1994) has investigated interactions between therapists and children with phonological difficulties.

Bunning (2004) attempts to elucidate intervention by applying theoretical frameworks drawn from sociological, medical and psychological literature to speech and language interventions. These are useful constructs for understanding intervention, and together with Leahy's (1995) chapter entitled "Philosophy in intervention" certainly go some way towards providing a much-needed theory of therapy. One of Bunning's (2004) aims is to draw together the range of specialisms within the speech and language therapy field, and highlight commonalties they share in terms of intervention. This is philosophically interesting but ultimately the frameworks may be too broad to account for the complex, highly-specific difficulties encountered by different client groups. Her frameworks may be helpful in carrying out a retrospective analysis of what occurred in an intervention episode, but would not be able to effectively inform intervention planning, for example for the children presented in this work.

Evidence-based practice offers guidelines for decision-making. Reilly (2004) emphasises the disparity that exists between clinical practice and research evidence, suggesting that in some cases although evidence exists it is not applied in clinical situations. She cites the example of Rousseau, Onslow, Packman and Robinson (2001) who investigated the Lidcombe programme for addressing stammering in young children. Only about 50% of clinicians were using the programme in the recommended way with most making compromises in terms of dosage to suit service delivery limitations, and selecting parts of the programme that they felt were relevant. This was despite published evidence from Onslow et al. (2001) that the programme is most effective when employed in a particular way. Therapists do bring specialized knowledge and intuition to the therapy process, but the extent to which art and science are implicated in intervention is debatable. The interventions described in this project have suggested that science and evidence are paramount in intervention planning. Good interpersonal skills and sensitivity will always have a place in intervention but these qualities are complementary rather than a substitute for science.

Rousseau et al. (2001) concluded that those therapists not using the programme were almost certainly carrying out interventions for which there is as yet no evidence of effectiveness. This finding, surely not specific to the area of dysfluency, raises two important issues. Firstly, as speech and language therapy is a relatively young profession it is not surprising that the academic underpinning of the work is limited. Demands for services and clinical priorities mean that academic underpinnings are often seen as added extras for the workforce rather than fundamental. Clearly, there is a need for theoretical underpinnings and this is something which needs to be strongly emphasised in undergraduate training courses and throughout professional development: Howell and Dean (1994) have suggested that speech and language therapists are in a unique position to synthesise knowledge from a variety of fields including that of clinical practice to 'create a viable theoretical underpinning for rehabilitation.' (p.2). Secondly, it should be noted that evidence-based practice guidelines do not necessarily define best practice since the evidence may be weak or insufficient to make that determination. The evidence-base needs to be critically judged and continually re-evaluated in the light of new evidence.

3.3 Contributions of this work

Chapter 10 concluded with a summary of theoretical contributions of this work. Building on these, this chapter has outlined further contributions – more specifically from a clinical perspective but with a strong awareness that theory and therapy can never be truly separated. The review of relevant studies in chapter 1 revealed limited work investigating tailor-made intervention for school-age children with persisting speech difficulties. Thus, the first contribution of this work is that of five new cases to the evidence-base. Beyond this, other contributions are as follows:

- Wide-ranging outcomes measures which can cover areas from 'macro' (i.e. intelligibility measures and standardised tests) to 'micro' (i.e. stimuli specific to the child and their intervention programme) in order to yield a comprehensive picture of any change occurring. Figure 11.1 provides a snapshot of change that occurred for each child at a range of levels.

- A procedure for evaluation of intelligibility pre- and post-intervention, and suggestions for future work in this area.

- Stimuli selection and generalisation as ways of informing both clinical practice and theory. Developmental hierarchies and productive phonological knowledge have been evaluated in terms of their importance for intervention planning. Consonant clusters were specifically considered in this chapter as an example of targets employed in different ways and for different reasons with two children.

- Connected speech has been emphasised as an aspect that may need to be specifically addressed, at least for some children. Theoretical frameworks have been used to explain why this may be the case. It may be the case that the traditional sequence of sound to word to connected speech should be reversed.

- Consideration of dosage and cost-effectiveness issues. Although it may be difficult to justify the great expenditure needed to carry out intensive, targeted interventions such as these, it has been shown that cost evaluations should be considered as a final aspect of evidence-building, and that evaluations of cost-utility may support such therapy.

- Support for the use of psycholinguistically-oriented intervention as a means for driving the intervention process in children with speech disorders, and used in combination with linguistic knowledge, in this case phonological analyses and theory.

- A written language profile to be used in conjunction with Stackhouse and Wells' speech processing profile and to encourage consideration of how these aspects overlap and integrate.

- Evidence for the effectiveness of tailor-made and intensive intervention for children with persisting speech problems.

- An emphasis on the links between theory and therapy which each case has attempted to exemplify.

4. CRITICAL EVALUATION OF THE STUDY

It is commonly acknowledged that intervention studies are fraught with challenges (e.g. Patterson, 2002). Whurr, Lorch and Nye (1992) observe that:

> "Certain aspects of research and therapy will always be difficult to reconcile. In practice, it is not always possible to control for all the variables one would wish. In such circumstances, it is important to specify which variables are being controlled and justify the choice of these controls."

Furthermore, research with developing children is considered a particular challenge (Enderby and Emerson, 1995). Many of the difficulties highlighted by these authors and outlined in the introductory chapters have been encountered in this research, despite awareness of such problems and attempts to include careful controls to overcome them.

One of the major and recurring difficulties has been in carrying out intervention tasks in a circumscribed way: ideally intervention tasks need to be carefully delineated so that one is able to state with preciseness how what one has targeted has affected the rest of the system. Tools such as psycholinguistic profiles and psycholinguistic models make task description easier and have greatly advanced the potential to do this, but it still remains a challenge to pinpoint only specific modules without indirectly targeting other areas. Ben and Rachel's interventions targeted fairly wide-ranging areas that made it difficult to pinpoint the effects of intervention in very specific ways. Because effective intervention, by definition involves scaffolding from task to task, and treating the speech processing system as a whole, (Rees, 2001b) there is a tension between the effectiveness aspects of treatment and the value that can be derived theoretically.

Some interesting findings were made regarding connected speech. However, only two children had connected speech measures explicitly included as part of their intervention or as controls. It is a limitation of the study that more connected speech controls were not included for other children, but at the same time a good example of how intervention can drive hypothesis building: connected speech had not been considered so carefully until the children's generalisation responses to intervention were observed. Similarly, non-words were not selected for Katie's control measures (neither in speech nor for spelling) and this limited interpretation of her progress. On the other hand, a fairly wide selection of control measures was selected for each child and it is impossible to include all controls that might reveal interesting findings. In terms of intelligibility, spontaneous speech remains a challenge to measure in a pre-[post fashion. Some attempt was made in the work described here, yet the results for spontaneous speech are not clear cut and necessarily reliable given the small number of spontaneous items included. Considering the centrality of spontaneous speech to intelligibility, it is an important limitation of the intelligibility study.

The small number of children included in the study has limited the conclusion which can be drawn about issues such as specificity of treatment: using a larger number of children might have allowed trends to emerge more clearly regarding the influence of factors such as a child's age or IQ on intervention outcome. However, these were not primary research questions and it has been argued that using a small number of children has allowed for the inclusion of a great deal of useful detail that would not have been included in a large group study. While this chapter has aimed to pull together findings from the children as a group, any conclusions must be viewed in the context of the small number of children participating in the project.

From an effectiveness point of view, intervention studies need to demonstrate that any changes observed are due to the intervention and not to other factors. This was demonstrated in this project by including case history data of the children to show that minimal progress had been made in the past, evidence for stable baselines prior to intervention, as well as results of other more general aspects of their school achievement to show that the improvements made were specific to the areas addressed in intervention. These are difficult issues and despite these attempts one might argue that minimal progress noted in the past was due to the fact that measures of that progress were very gross (e.g. mainly standardised tests) and that children may have infact been making progress that was simply not measured. Furthermore, it is difficult to separate out which aspects of the speech and language intervention brought about the changes noted, e.g. what was the relative contribution of the relationship with the therapist, and the opportunity to listen to an adult in a focused, quiet environment? These questions are hard to answer and remain challenges of intervention studies. It is suggested that the controls incorporated in the case studies go some, if not all the way toward ensuring that the conclusions drawn are reasonable ones. Maintenance of change is also an important consideration. For each of the children, long-term follow-up took place several months after intervention to ensure that recency effects had not been responsible for any gains observed immediately post-intervention.

Intervention studies provide a longitudinal perspective. The children presented here were evaluated and treated over the course of an 18-month period. For some of the children with severe difficulties, it became clear that a great deal of further intervention was warranted. Thus, the picture provided of the children's speech, language and literacy changes is only a snapshot of the story. However, given the complex and possibly lifelong influence of these difficulties (Stothard, Snowling, Bishop, Chipchase and Kaplan, 1998), this snapshot view is inevitable.

It is always important to consider the quality and level of evidence supplied (Reilly, 2004). According to Robey and Schultz's (1998) phase model the evidence presented here is Phase I and II evidence. This is a relatively early but essential stage of evidence building. It is important to interpret the evidence as such, and to consider it as a contribution to the basis of further outcomes work carried out at later phases of the hierarchy.

5. CONCLUSIONS AND FUTURE DIRECTIONS

This research has raised many questions about intervention, and opened many avenues for further enquiry into children's speech processing difficulties. Some of these are outlined in this section, including: 7.1 development of Stackhouse and Wells' (1997) speech processing model, 7.2 development of a psycholinguistic database for the systematic collection of intervention evidence, 7.3 further investigations of intelligibility, and 7.4 consideration of dosage and delivery issues.

5.1 Model development

Stackhouse and Wells' (1997) model has been shown to account for the speech and language processing taking place in five children presented in this work. However, the model is underspecified, at times giving only a gross estimation of the difficulties being faced at a particular level. Indeed, if we consider that Stackhouse and Wells have accurately delineated *levels of processing*, then the next logical step would be to attempt to further specify subcomponents at each of these levels. Considering the model in a developmental context is vital, and the subcomponents at each level might involve the inclusion of specified developmental phases. For example, it could be stated that a child has a difficulty with phonological representations, and more specifically this is because they are stuck at an earlier developmental phase than would be expected in terms of chronological age. An attempt has been made to combine this developmental perspective into the motor programming level (chapter 10, section 1.3.1.). Future work might expand other modules in the same way, thus creating a cognitive neuropsychological model that is truly developmental, and more highly specified than it stands at present. Harley (2001) notes that there is an imbalance between the amounts of research that have been done on language comprehension and input, and speech production. He suggests that this is because input work can control for aspects of language rather carefully (e.g. the imageability, frequency of visual or auditory signals) but that output is more challenging to control for – "our thoughts are much harder to control experimentally." (p.349). There is clearly a great need for more research on output speech production and motor programming. There is also a need to bring speech and literacy closer together within a psycholinguistic framework. Links between spelling and speech are relatively unexplored, and certainly spelling should be routinely included as an outcomes measure for phonological interventions where possible.

Much of the model building, assessment and intervention has focussed on single words – it would be useful to carry out research investigating more specifically single word and connected speech processing, so that the interface between the two areas can be elucidated. Future intervention studies should include a wider range of connected speech outcomes measures since this is an area about which relatively little is known. Wide ranging outcomes measures ensure that a complete picture of generalisation effects is obtained, and this seems like the best way of approaching the generalisation issue, a vital one of equal importance from both theoretical and clinical perspectives.

5.2 A psycholinguistic database

The importance of single case study interventions in informing our knowledge of speech and language processing has been emphasised throughout this thesis. There remains a great need for further work of this nature to build on the evidence-base for this type of work. It is suggested that such studies should be added to a web-based database that could be used by clinicians and researchers to build on knowledge in this area. Children with speech and language difficulties form a heterogeneous group. Case studies such as the ones presented here reveal wide variation between children, but also show commonalities in their responses to intervention. Profiling and subgrouping approaches such as those outlined by Stackhouse and Wells (1997) and Dodd (1995) give useful frameworks for carrying out assessment and planning intervention. It is suggested that a greater body of intervention studies be carried out using these frameworks so that a database of children's profiles and their responses to intervention might be developed. From a theoretical point of view such a database would allow one to look for generalisation trends across a range of children, which could be analysed in terms of variables such as age, profile of difficulties and amount of intervention given.

5.3 Intelligibility

Intelligibility should be routinely used as an outcomes measure when working with children with speech disorders. There is much work to be done in this area, including refining and developing a way of reliably evaluating the intelligibility of spontaneous speech before and after intervention. Furthermore, ongoing links should be made with outcomes to yield a longitudinal picture of how changes in speech feed in to intelligibility.

Intelligibility norms are limited and ones available are not necessarily applicable to British children (e.g. ASHA, 1987). Future work needs to be carried out to investigate the development of intelligibility in children with normally-developing speech. Using speech recognition software, computers may have some role in the clinical situation for a more practical way of evaluating intelligibility. The development of such a tool may be some way away, but it holds promise of being an important and potentially valuable clinical and research tool.

5.4 Dosage and delivery

Discovering optimal intervention dosage remains a pressing need. One potential way of addressing this problem and coping with cost-effectiveness issues may be through using intensive computer-based interventions. Comparisons of, for example, computer-based interventions v. learning support assistants for reliable delivery of speech and language programmes in schools would be helpful. This would require:

- Development of a flexible, user-friendly software application to support assessment and intervention for children with speech-disorders.
- Creation of computerised tasks and games to be used for children's speech and language assessments.
- Creation of computerised forms for the storage of information arising from such assessments.
- Creation of computerised tasks and games to be used in intervention for children.

Stackhouse and Wells' psycholinguistic framework has already been used as a theoretical basis for a software application addressing *input* aspects of the model (Roulstone and Wren, 2001), but there is further scope for development of other aspects of the framework (e.g. games for speech *output* work).

5.5 Concluding comments

Opening chapters of this thesis emphasised the challenges facing intervention researchers: Patterson (2002 p.570) described the 'daunting prospect' of properly designed and executed intervention research, and the fact that the potential to learn something of real theoretical significance from the outcome of treatment may not always be apparent (or convincing). Many of the challenges outlined by Patterson, and others (e.g. Enderby and Emerson, 1995) have been experienced in the present study. However, these 'investigations of intervention' have offered contributions to both clinical and theoretical issues regarding children's speech processing, and attempted to show that the divide between theory and therapy is not as great as authors such as Patterson (2002) have supposed. Intervention studies certainly pose unique challenges, yet they can contribute to a meaningful evidence base, bring about changes in clinical practice (Carding and Hillman, 2001) and offer glimpses into the "complex, multilayered and dizzying" reality of children's speech and language processing (Chapman, 2000 p.45).

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APPENDICES

1. Parental consent and information sheet for participants
2. Non-standardised or unpublished tests
   a. Input assessments:
   b. Output assessments:
3. Child Interview questions
4. Katie: Connected speech stimuli
5. Joshua: Example of a social story used as context for introducing new words.
6. Stimuli used for the intelligibility procedure
7. Instructions given to listeners in the intelligibility procedure
8. Bryan and Howard's (1992) scoring guidelines used for the intelligibility procedure

Appendix 1.
Parental consent and information sheet for participants

CLIENT INFORMATION SHEET AND CONSENT FORM

Study Title
Intervention for children with speech and language difficulties

Introduction
You and your child are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether your child will take part. Thank you for reading this.

What is the purpose of the study?
This project is concerned with intervention for school-aged children who have difficulties with their speech, language and literacy.

It is important that we understand how the intervention process brings about change in individual children's speech and language and why intervention is more successful for some children than others.

For this project, a registered speech and language therapist will provide assessment and therapy using standard task widely used by therapists throughout the United Kingdom.

The study is in two parts. First, children's speech and language skills (including literacy) will be assessed. The assessment part of the study will enable us to decide if your child will be a suitable participant for the intervention phase, and will give you the opportunity to decide whether you would consider your child's further involvement. Second, an intervention programme will be carried out with a small number of children.

Children who participate in the second phase of the study will receive a programme of speech and language intervention that is designed to meet their individual needs, and will be delivered in a predominantly but not exclusively one-to-one setting. The therapy programme will take place at your child's school or the university clinic over a clearly defined timescale on days and times that are arranged through mutual agreement.

The project aims to increase our understanding of the nature of children's speech and language difficulties, and how best to help them.

Why has my child been chosen?

Children with persisting speech and language difficulties are the focus of this research, and your child may fall within this broadly defined group. Children are recruited to this study via speech and language therapy services, charitable organisations, schools or through direct contact with the investigators. The assessment will give us an opportunity to decide whether your child will be suitable for the intervention part of the study, and if you wish to pursue this.

Does my child have to take part?

No. It is up to you to decide whether or not you wish your child to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of care your child receives.

What will happen to my child if s/he takes part?

The first step will involve a speech and language assessment. If you are able to be present at this first meeting, the speech and language therapist will chat to you about your child, explain the assessment process in further detail, listen to your concerns or questions about your child and encourage you and your child to ask any questions that you might have about speech and language or the project. If you are not able to be present (e.g. because your child is seen at school) alternative opportunities for discussion will be made. In the assessment your child will be asked to say words and sentences, look at pictures, tell stories, make rhymes and other various tasks related to listening, talking and remembering.

After the assessment we will give you a report outlining our findings. We will discuss these with you and answer any questions you have. If you child is recruited to the second (intervention) phase of the study, we would arrange suitable days, times and venues in which the intervention would take place.

Intervention may be offered in a clinic or in your child's school. In most cases intervention would be offered on a twice-weekly basis for 30 minutes. A finite course of intervention would be agreed on.

Intervention will be designed for your child and most typically carried out on an individual basis, although small group sessions may also be appropriate. Each session would involve games and activities designed to promote relevant aspects of your child's speech or language.

What are the possible disadvantages and risks of taking part?

There are no known risks associated with speech and language therapy. Normally children enjoy the games and activities carried out. Children' speech and language skills typically improve at varying rates in speech and language therapy. Some children may make slow progress. Your child's progress will be discussed with you.

What are the possible benefits of taking part?

We hope that the intervention helps your child. However, this cannot be guaranteed. The information we get from this study may help us to assist children with speech and language difficulties better in the future.

What happens when the research study stops?

Intervention is offered on a clearly defined timescale. We will be unable to offer further blocks of intervention once this study has been completed even if further intervention may be needed. Your child's involvement in this study will not affect their access to the NHS speech and language therapy service offered in your area. Throughout we will liase with the appropriate people in the NHS/Education services involved with your child.

What if something goes wrong?

If you have any cause to complain about any aspect of the way in which you have been approached or treated during the course of this study, you should contact your local speech and language therapist who is involved with this study. Normal NHS complaints mechanisms are available to you and are not compromised in any way because you have taken part in a research study.

Will my child's taking part in this study be kept confidential?

All information that is collected about your child during the course of the research will be kept strictly confidential. With your consent, video and audio recordings may be taken in order for us to carry out a more detailed analysis of your child's session. With you further consent these could be used together with other data for clinical teaching as well as research purposes. Your name and address will be removed from any of the data.

What will happen to the results of the research study?

A qualified and registered speech and language therapist is undertaking this research as part of the requirements for a postgraduate (PhD) degree through the Human Communication Sciences Department at the University of Sheffield. The data will be presented and discussed anonymously in the final report submitted to the university for examination at the completion of the research. With your consent, the data may also be presented in articles submitted to academic journals or books for publication in order to disseminate the findings to practitioners and researchers, and for the purpose of teaching student speech and language therapists. Your child will not be identified in any report or publication. You will have access to any of these reports or papers.

Who has reviewed the study?

The South Sheffield Local Research Ethics Committee and the Research Committee of the Department of Human Communication Sciences, University of Sheffield have reviewed this research.

______________________________ ***Tear off here*** ______________________________

- ☐ I have read the attached information sheet and I DO / DO NOT (delete as applicable) give permission for my child ____________________________________ (child's name) to take part in the research study.

- ☐ I DO / DO NOT (delete as applicable) agree that data arising from any session(s) can be used for research and teaching purposes, and consent to video / audio recordings being used for this same purpose.

____________________________	__________	______________
Name of parent/legal guardian	**Date**	**Signature**

Appendix 2.

2a. INPUT TASKS

Level B: Non-word discrimination test (Bridgeman and Snowling, 1988)

Aims: To determine a child's ability to discriminate between closely-related non-words

Procedure: Examiner reads paired words, and child is required to state if they are the same or different

Practice items:

/vɒs – vɒt/
/fest - fets/
/vɒst – vɒts/
/tet – tet/

Test items:

/kest – kets/	/bleɪst – bleɪts/
/bleɪs – bleɪt/	/fɒts – fɒst/
/zet – zet/	/vɪts – vɪst/
/fɒt – fɒs/	/bɪs – bɪs/
/kes – ket/	/jeɪts – jeɪst/
/dɪts – dɪst/	/dɪt – dɪs/
/vɪt – vɪs/	/pəut – pəut/
/pəuts – pəuts/	/jeɪs – jeɪt/
/zets – zets/	/bɪst – bɪst/

Normative data: Cited in Bridgeman and Snowling (1988), Constable et al. (1997) and Vance (2001).

Level D: Real-word discrimination test (Bridgeman and Snowling, 1988)

Aims: To determine a child's ability to discriminate between closely-related real words

Procedure: Examiner reads paired words, and child is required to state if they are the same or different

Test items:

kit – kit	rates – raced
hits – hissed	tots - tossed
messed – messed	tot - toss
guess – get	miss - mitt
race – rate	hit - hiss
mitts – missed	goats - goats
plate – place	met - met
guessed – gets	placed - plates
kissed – kissed	goat – goat

Normative data: Cited in Bridgeman and Snowling (1988); Constable et al. (1997) and Vance (2001).

Level E: Own error discrimination test (Locke, 1980a, b)[27]

Instructions for the Speech Perception / Production Task from
For any sound being produced in error, it is possible that the error is due to an inability to hear the difference between what they produce and the target. This procedure is intended to allow one to determine if this is the case. Each form can accommodate testing for 2 different speech errors.

1. Under "production task", list the target word and the substitution. For example if the child said 'fumb' for "THUMB": thumb -> fumb

2. Indicate the target sound in the space marked Target ("th" in the above example), the substituted sound in the space marked Error ("f" in the above example), and a related sound as a control in the space marked Control ("s" might be a good one for the above example).

3. In each of the 18 spots under "Stimulus - Class" fill in the appropriate sounds from #2 above depending on which item is listed. For example if the item says Target, write "th", if it says Error write "f", and if it says Control write "s". This creates the stimuli for the test.

4. Using the target picture as the visual cue, ask the speaker to judge whether or not you said the right word. For example:
   1. Is this "some"?
   2. Is this "fumb"?
   3. Is this "thumb"?
   4. Is this "thumb"?
   5. Is this "fumb"? Etc.

   If the child answers "yes", circle yes next to the item. If they answer "no" circle no.

5. Anytime the word "yes" or "no" appears in upper case letters, that indicates the correct response. If it is in lower case letters that indicates it would be a mistake in perception.

6. Count the mistakes (the number of lower case responses) in each category (Target, Error, Control).

7. The child is said to have a problem with perception if 3 or more mistakes in perception are noted in response to the Error stimuli. Since there are 6 possible Error stimuli the child has then produced at least 50% incorrect responses and thus appears to be having trouble distinguishing what they usually say from what they should be saying.

8. Repeat the process for each sound the child makes errors on.

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[27] Instructions from Flipsen (2002)
http://health.groups.yahoo.com/group/phonologicaltherapy/files/DECISION%20TREE/

Level E cont.: **Own error discrimination test (Locke, 1980a, b) test form[28]**

Date:		Date:	
Production Task / / -> / /		Production Task / / -> / /	
Target / / Error / / Control / /		Target / / Error / / Control / /	
Stimulus - Class	Response [2]	Stimulus - Class	Response [2]
1. / / - Control	yes - NO	1. / / - Target	YES - no
2. / / - Error	yes - NO	2. / / - Control	yes - NO
3. / / - Target	YES - no	3. / / - Target	YES - no
4. / / - Target	YES - no	4. / / - Control	yes - NO
5. / / - Error	yes - NO	5. / / - Error	yes - NO
6. / / - Control	yes - NO	6. / / - Error	yes - NO
7. / / - Control	yes - NO	7. / / - Target	YES - no
8. / / - Target	YES - no	8. / / - Error	yes - NO
9. / / - Error	yes - NO	9. / / - Target	YES - no
10. / / - Target	YES - no	10. / / - Control	yes - NO
11. / / - Error	yes - NO	11. / / - Control	yes - NO
12. / / - Control	yes - NO	12. / / - Error	yes - NO
13. / / - Error	yes - NO	13. / / - Target	YES - no
14. / / - Target	YES - no	14. / / - Control	yes - NO
15. / / - Control	yes - NO	15. / / - Error	yes - NO
16. / / - Error	yes - NO	16. / / - Target	YES - no
17. / / - Target	YES - no	17. / / - Error	yes - NO
18. / / - Control	yes - NO	18. / / - Control	yes - NO
Mistakes: Error ____ Control ____ Target____		Mistakes: Error ____ Control ____ Target____	

Level E: Auditory lexical decision test (Constable et al., 1997)

Aims: To test the precision of a child's phonological representations

Procedure: Examiner reads paired words: one a familiar word and the other a similar sounding non-word. The child is required to state if they are the same or different.

Test items:	Pair non-word A:	Paired non-word B:	Real-word distractor
hospital	[hɒspɪpəl]	[hɒstɪpəl]	eskimo
elephant	[ɛlɪlənt]	[ɛfɪlənt]	president
crocodile	[krɒkəkaɪl]	[krɒdəkaɪl]	porcupine
microphone	[maɪkrəkəʊn]	[maɪfrəkəʊn]	telephone

[28] Test form from Flipsen (2002)
http://health.groups.yahoo.com/group/phonologicaltherapy/files/DECISION%20TREE/

octopus	[otətəs]	[opətəs]	octagon
escalator	[ɛskəleɪkə]	[ɛstəleɪkə]	alligator
binoculars	[bɪnɒkjunəz]	[bɪlɒkjunəz]	rhinocerous
helicopter	[hɛlɪkɒpkə]	[hɛlɪtɒpkə]	radiator
television	[tɛlɪlɪʒən]	[tɛvɪlɪʒən]	competition
caterpillar	[kætətɪlə]	[kæpətɪlə]	calculator

Normative data: cited in Constable et al. (1997)

Level E: Auditory-visual lexical decision test (Constable et al., 1997)

Aims: To test the precision of a child's phonological representations

Procedure: Examiner presents child with a picture (e.g. CATERPILLAR). Words are named (using the lists outlined above), and the child is required to determine if the words are appropriate for the picture, e.g. is it a [kætətɪlə]?
is it a [kæpətɪlə]?

Level F: Rhyming test (Vance et al., 1994)

Aims: To determine a child's ability to identify rhyming words using picture stimuli only to access phonological representations

Procedure: Examiner shows child three pictures; child is required to point to two items which rhyme

Practice items:
P1 nail whale hammer
P2 bell ball shell
P3 heart dart star
P4 tap cap top
P5 log tree dog
P6 door deep four

Test items:
1. cat fish mat
2. peg leg pig
3. ball bell wall
4. purse bag nurse
5. chair bear table
6. key cow tea
7. spoon moon knife
8. house mouse horse
9. goat gate boat
10. sock shoe clock

Normative data: Cited in Vance et al. (1994).

2b. OUTPUT TASKS

Level G: Single word naming test (Constable et al., 1997)

Aims: To determine a child's ability to access appropriate word labels

Procedure: Examiner shows pictures and child required to name them

Items:
hospital
elephant
crocodile
microphone
octopus
escalator
binoculars
helicopter
television
caterpillar

Normative data: Cited in Constable et al. (1997).

Level I: Real word repetition subtests (Constable et al., 1997)

Aims: To determine a child's ability to repeat familiar words

Procedure: Examiner reads words (listed above) and child required to repeat them

Level I: Real word repetition (Snowling)

Aims: To determine a child's ability to repeat familiar words

Procedure: Examiner reads words (listed above) and child required to repeat them

Items:
enemy
eskimo
melanie
anemone
buttercup
slippery
hazardous
spaghetti
ambulance
christopher
statistics
instructed

Level J: Non-word repetition subtest (Constable et al., 1997)

Aims: To determine a child's ability to repeat unfamiliar words

Procedure: Examiner reads words and child required to repeat them verbatim

Test-items:

[hɒspɪpəl]	[hɒstɪpəl]
[ɛlɪlənt]	[ɛfɪlənt]
[krɒkəkaɪl]	[krɒdəkaɪl]
[maɪkrəkəʊn]	[maɪfrəkəʊn]
[otətəs]	[opətəs]
[ɛskəleɪkə]	[ɛstəleɪkə]
[bɪnɒkjunəz]	[bɪlɒkjunəz]
[hɛlɪkɒpkə]	[hɛlɪtɒpkə]
[tɛlɪlɪʒən]	[tɛvɪlɪʒən]
[kætətɪlə]	[kæpətɪlə]

Level J: Non-word repetition (Snowling)

Aims: To determine a child's ability to repeat unfamiliar words

Procedure: Examiner reads words and child required to repeat them verbatim

Test-items: Derived from Snowling real-words listed above. The non-words should be pronounced by analogy with the real words form which they were derived, retaining stress as far as possible.

ineby
istibo
beladie
adebole
muddercup
swibbery
hassarpus
skappedi
andurant
gritother
spapistics
inspructid

Appendix 3.
Child Interview questions

1. You've been coming to me for speech therapy for a while now – what do you think about it?

   Probes / prompts: - What do you think about the things we do together?
   - What do you like best?
   - What don't you like?
   - What do you think about the tape / video / being recorded?

2. You've had speech therapy with other ladies before – what did you think about that?
   Probes / prompts: - What can you remember doing?
   - What did you like?
   - What didn't you like?
   - Was it the same as what we do or was it different?

3. Why do you come for speech therapy?
   Probes / prompts: - do you think it has helped your speech?
   - How do you think it helps children talk better?
   - Would you like to be a speech therapist one day?
   - Do you like talking – what is nice about it?
   - What is hard about talking?
   - What would happen if we couldn't talk?
   - Do you like listening to other people talk?
   - What happens when someone doesn't understand you?
   - What happens when you don't understand someone?
   - Why do you think talking is important?
   - Why do you think listening is important?
   - Do we all speak the same language?
   - Even if we speak English, do we all sound the same?

4. Let's talk about reading and writing – do you like to read and write?
   Probes / prompts: - Why? (what do you like and what don't you like?)
   What do you think about the reading / writing things we have done together?
   Why do you think reading and writing are important for children?
   Do you think reading and writing have anything to do with speech?
   Which is easier for you – reading or writing?

5. Let's talk about school now – what do you think about school?
   Probes / prompts: - What is the best thing about school?
   What don't you like about school?
   Would you like to come for more / less speech therapy?
   Would you like to talk more / less in the classroom?
   Would you like to do more / less reading and writing?

Appendix 4.
Katie: Connected speech stimuli

LIST A		1 = Facilitatory sentences 2 = Neutral sentences 3i = Most challenging sentences (hetero-organic adjacent consonants without assimilation) 3ii = Sentences not directly addressed (assimilation final consonants in stimulus words)
No.	Stimulus Word	Sentences
1	note	1: This note teaches father Xmas 2: There's a note under the table (3ii: This note can't be read)
2	plane	1: The plane knocked it 2: There's a plane in the sky (3ii: This plane must be loaded)
3	heart	1: This heart tastes nice 2: There's a heart on my jumper (3ii: This heart can break)
4	nail	1: This nail looks pretty 2: There's a nail in the wood 3i: This nail got painted twice
5	cage	1: The cage joined my class 2: There's a cage on the bed 3i: The cage got stolen
6	slide	1: This slide dumped me 2: The slide in the park is nice (3i: The slide bounces him)
7	wheel	1: The wheel looks broken 2: There's a wheel on the bike 3i: This wheel got fixed
8	rake	1: This rake cost £10 2: There's a rake on the ground 3i: This rake takes a bath
9	stork	1: The stork carries a baby 2: There's a stork on the log 3i: This stork teaches swinging
10	leaf	1: The leaf feels wet 2: The leaf is in the air 3i: This leaf got torn
11	sauce	1: The sauce seems nice 2: There's sauce in the jar (3ii: The sauce shouldn't burn)
12	ice	1: This ice seems cold 2: The ice is in the bucket (3ii: This ice should melt)
13	soap	1: This soap pulled my hair 2: There's soap on the towel 3i: This soap got soft
14	pipe	1: The pipe pushes through the roof 2: There's a pipe on the wall 3i: This pipe curls round the floor
15	barn	1: The barn needs painting 2: There's a barn on the farm (3ii: The barn must be cleaned)
16	road	1: The road divides the hill 2: There's a road over the river (3ii: This road brings us home)

LIST B		1 = Facilitatory sentences 2 = Neutral sentences 3i = Most challenging sentences (hetero-organic adjacent consonants without assimilation) 3ii = Sentences not directly addressed (assimilation final consonants in stimulus words)
No.	Stimulus Word	Sentences
1	boat	1: This boat tires them all 2: There's a boat in the harbour (3ii: This boat cost £50)
2	rain	1: The rain knocks him 2: There's rain outside (3ii: The rain makes puddles)
3	cart	1: This cart tips over 2: There's a cart in the road (3ii: This cart can't stop)
4	whale	1: This whale likes him 2: There's a whale in the sea 3i: The whale got hungry
5	age	1: Your age joins mine 2: There's his age on his shirt 3i: Your age goes up
6	hide	1: To hide does seem naughty 2: There's a game of hide and seek (3ii: Hide behind the bush)
7	seal	1: This seal loves sleeping 2: There's a seal in the sea 3i: The seal got caught
8	cake	1: The cake cools down 2: There's a cake on the table 3i: This cake tastes delicious
9	fork	1: This fork cost £1 2: There's a fork on the table 3i: The fork fell on the floor
10	half	1: This half fell on the floor 2: There's half in the glass 3i: This half got cold
11	fleece	1: His fleece seems clean 2: There's fleece on the floor (3ii: Their fleece should be washed)
12	slice	1: That slice seems small 2: There's a slice on her plate (3ii: The slice should be bigger)
13	rope	1: This rope pulls the car 2: There's a rope on the metal 3i: This rope keeps them together
14	peep	1: To peep pleases him 2: She likes to peep at me 3i: To peep can be naughty
15	dawn	1: This dawn nearly begins 2: It's the dawn of a new day (3ii: The dawn makes me happy)
16	sword	1: The sword dirtied me 2: There's a sword over his head (3ii: The sword burnt his hand)

GROUP C		1 = Facilitatory sentences 2 = Neutral sentences 3i = Most challenging sentences (hetero-organic adjacent consonants without assimilation) 3ii = Sentences not directly addressed (assimilation final consonants in stimulus words)
No.	Stimulus word	Sentences
1	goat	1: This goat talks too much 2: There's a goat on the grass (3ii: The goat kicks his heels)
2	train	1: The train needs fixing 2: There's a train under the tree (3ii: This train must stop)
3	part	1: This part tastes nice 2: There's part of the present (3ii: This part can't break)
4	hail	1: This hail looks horrid 2: There's hail outside 3i: The hail goes everywhere
5	page	1: This page jumps up 2: There's a page under the bed 3i: The page got dirty
6	lied	1: He lied daily 2: He lied outside the front door (3ii: He lied badly
7	kneel	1: To kneel looks nice 2: He likes to kneel on the branch 3i: To kneel gets sore
8	steak	1: This steak cost £2 2: There's a steak in the fridge 3i: The steak tastes delicious
9	walk	1: This walk cools me 2: They like to walk outside 3i: The walk took all day
10	hoof	1: This hoof feels sore 2: He put his hoof on the wood 3i: His hoof got hurt
11	purse	1: This purse seems empty 2: There's a purse on this page (3ii: The purse shouldn't get lost)
12	dice	1: The dice seems broken 2: There's a dice on the floor (3ii: This dice should be lucky)
13	grape	1: This grape pushes the pear 2: This grape on the board is old 3i: One grape got squashed
14	sheep	1: This sheep pushes his friend 3: There's sheep under the table 3i: The sheep got in the picture
15	line	1: This line needs finishing 2: There's a line under my name (3ii: The line might be skew)
16	toad	1: The toad dances for him 2: There's a toad on the leaf (3ii: The toad burps loudly)

Appendix 5.
Joshua: Example of a social story used as context for introducing new words

1.

A Story About
Lining Up

2.

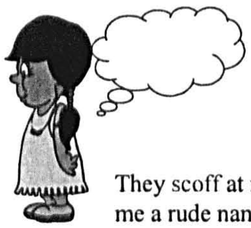
When I hear the bell, its time to line up.

All the children in my class stand in a line.

Sometimes we stand quietly.
Nobody touches me. Nobody annoys me.
My teacher praises me.

3.

Sometimes a sly person will touch me.



They scoff at me and call me a rude name. They try to hurt me or sneer at me.

4.

Then I get in an angry state.

I hurt them. I get into trouble because somebody else was sly.

5.

I will try to stay in a calm state
when we line up.
If other sly children do bad things like scoff and smirk at me, I will try to ignore them.

6.

I am a good boy who deserves to be praised by my teacher.

The end

Appendix 6.
Stimuli used for the intelligibility procedure

Child	Single Words	Repeated Sentences	Spontaneous Sentences
Oliver	cat	Not Applicable	dayle won the race
	cage		no he did not
	sad		here's the pencil / found my pencil
	jet		where's that purse
	toe		what is it?
	cap		my mom got that
	cup		what is he(that) called?
	jab		don't know where his mummy
	sack		where is daddy
	tight		you do mine
	make		me do all
	coach		
	age		
	coil		
	rock		
	key		
	clown		
	helicopter		
	snail		
	worm		
Katie	rake	the hail goes everywhere	they like to walk everyday outside
	note	the walk took all day	can you count it now, then we put it all back there
	sword	there's a seal in the sea	he's going to look after my fish
	nail	the purse shouldn't get lost	I used to have a parrot and he ran away
	leaf	the train needs fixing	
	line	that slice seems small	
	kneel	the fork fell on the floor	

Katie cont.	train page goat fish sugar cup snake crocodile hospital monkey wings garage queen	the cart tips over the barn needs painting there's a steak in the fridge	
Joshua	quit spite state smirk fled snake train queen bridge smoke aeroplane fruit window owl dice camel mermaid moon	didn't the rabbit eat the carrot? the boy was not chased by the girl then he fell in the water but the bus had to go on alone the ball weren't / was not thrown by the girl or the boy he saw a cow and the cow said moo he jumped over a fence the train went in the tunnel there was a naughty bus I went to the chip shop	can we play that piggy game then she took them for their dinner I'm not allowed to open it on Friday And I got a tracksuit

Joshua cont.	moon finger kite		
Rachel	gasp jest feast dusk disc spanner spider stool skunk skirt strawberry spray grass soap mouse garage duck umbrella microphone flower	was the car followed by the police? the man won't buy it the girl did not like the boy who lived down the street Did the boy kick the ball the train was followed by the car The cat didn't follow The man who painted the railing was very kind She changed the colour of her hair He amazed people with magic tricks He judged the competition	And this man is swimming with his clothes on we went on a real rollercoaster and it were scary (10) he gets me about 5 packets of crisps they always call us names and I do not like it
Ben	stack gust ship chair peach rake edge	the man who sits next to the/a tree is our mayor the man next door promises to water our flowers on holiday the boy sent a letter to the lady who moved away last year he was/were late for work the big brown dog chased the red ball the girl lived down the street the mouse/dog chased the ball	how much hair does he have on I had a little one but it got broken some are from (a) different word I pass you a picture like 'cat', you got to find 'cat'

Ben cont.	edge them jerk bathe faith shoot chin shirt tooth stamps clouds toothbrush red scissors	the mouse/dog chased the ball the dog chased the cat the boy and the girl picked the flowers wasn't the ice cream bought by the girl	

Appendix 7.
Instructions for the listeners in the intelligibility procedure

I am going to play you some samples of children's speech. Listen carefully and then write down what you think each child is saying. I want you to guess what real, English word - or words - they are saying.

Remember:

- Don't use phonetic transcription!
- All the children are saying proper English words you need to guess what they are.
- They are all children from Sheffield
- If you don't know what the child is saying try to make a guess, but put a line if you really can't guess.
- There is no right or wrong answer. The important thing is to guess at what you hear.
- I can only play each sample for you once.
- If I'm going too fast, please put your hand up or just shout STOP as I can stop the tape at any time for you and help you with your questions.
- If you do get left behind – just put a line and move on the next numbered item you hear.

Let's do two practice examples now. Can you find P1 on your sheet. Now I'll play the tape and remember to take a guess at what you hear.

Appendix 8.
Bryan and Howard (1992) scoring guidelines used for the intelligibility procedure

Method of Calculating proportion of consonant features correct: adapted from Bryan and Howard (1992, p.362-363)

The stimulus (as played on the CD) and response (as written by the listener) are compared. Where the number of syllables in the response is the same as the number of syllables in the stimulus, consonants in the response are compared with the consonants in the same position in the stimulus. Where there are added consonant(s), creating a cluster in the response, the consonant (s) with the lowest feature similarity with the stimulus consonant is discounted. Where there are fewer syllables in the response than in the stimulus, syllables are deleted from the stimulus to maximise the resulting similarity score. Consonants in the response do not have to occur in the same syllabic position as in the stimulus to score for feature similarity. So in a CVC response to a CVCV stimulus, the syllable final C in the response is scored for it similarity to the syllable-initial second consonant in the stimulus.

The number of different features counted are:

(a) voicing: voiced (including partially devoiced) / voiceless
(b) manner of articulation: plosive / affricate / fricative / nasal / liquid
(c) place of articulation: labial (including bilabial and labiodental) / alveolar (including dental, alveolar, palatoalveolar and palatal) / velar / glottal

The number of features that have identical values in the stimulus and the response are then counted. Each consonant can have 0-3 identical features. The total number of identical features in the response are divided by the total number of features in the stimulus (i.e. the number of consonants in the stimulus X 3) to give the proportion of features correctly reproduced for that stimulus item.

Examples:

(a) Listener writes <body> for child's production of PONY. Score = 4/6
The first consonant scores 2/3 for place and manner, and the second 2/3 for place and voice

(b) Listener writes <an> for child's production of HAMMER. Score = 2/6
The first consonant is not represented by the listener (0/3), and the second consonant scores 2/3 for shared voice and manner.