Children with persisting speech difficulties: Exploring speech production and intelligibility across different contexts

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Volume I

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Abbreviations and conventions

Abbreviation	
ALD	Auditory lexical decision
ALSPAC	Avon Longitudinal Study of Parents and Children
ASHA	American Speech and Hearing Association
C	Consonant
CA	Chronological age
CAS	Childhood apraxia of speech
CCD	Common clinical distortions
Conv.	Conversational speech
CS	Conversational speech
CSP	Connected speech processes
CVC	Consonant-vowel-consonant (and thus CVCVC etc.)
DDK	Diadochokinesis
DEAP	Diagnostic Evaluation of Articulation and Phonology (Barbara Dodd, Hua, Crosbie, Holm, & Ozanne, 2002)
DVD	Developmental verbal dyspraxia
EPG	Electropalatography
FCD	Final consonant deletion
GP	General practitioner (family doctor in the UK)
ICD	Initial consonant deletion
IPD	Inconsistent Phonological Disorder
IQ	Intelligence quotient
L1, L2 etc.	Listener 1, listener 2: the anonymised adults who completed the intelligibility task
MW	Multi-word
MWU	Multi-word utterance/s
N/A	Not applicable
NHS	National Health Service
PCC	Percentage consonants correct
PCC-A	PCC-adjusted measure (does not include CCD)
PCC-late 8	Measure of PCC of the last 8 segments which children acquire in typical development
PPA	Phonological process analysis
PPC	Percentage phonemes correct
PSD	Persisting speech difficulty
PVC	Percentage vowels correct
RCSLT	Royal College of Speech and Language Therapists
S.D.	Standard Deviation
SFWF	Syllable final word final
SFWW	Syllable final within word
SIWI	Syllable initial word initial

SIWW	Syllable initial within word
SSD	Speech sound disorder
SW	Single word(s)
T1	Time 1; time of first assessment
T2	Time 2; time of second assessment
V	Vowel
WSD	Weak syllable deletion

Conventions

Small capitals e.g. CAT: Spoken real word target(s); naming or repetition

Note re appendices 3.3 to 3.20: these task and score sheets are reproduced from *the Compendium of Auditory and Speech Tasks* (Joy Stackhouse, Vance, Pascoe, & Wells, 2007). Every effort has been made in the accuracy of the reproduction of the stimuli but spacing and headings have been changed where necessary for clarity. There are also some changes that occurred in the process of scanning in the documents which are visible on a few of the score sheets.

Abstract

Children with persisting speech difficulties: Exploring speech production and intelligibility across different contexts

Background and purpose

Children with persisting speech difficulties (PSD) may present with severe and ongoing impairments in segmental and prosodic output which can result in poor intelligibility. The purpose of this study was to examine the speech processing skills and intelligibility of four children with PSD, carrying out detailed phonetic and phonological analysis, and investigation of their speech output and intelligibility in single words (SW) and multi-word utterances (MWU).

Method

Participants were aged 6;5 to 7;3 at the start of the study. Their speech processing was examined through:

- Psycholinguistic assessment of input and output processing skills (Joy Stackhouse & Wells, 1997)
- Perceptual transcription and analysis of the production of SW, imitated sentences and conversational speech (CS) at two points in time (T1 and T2). Speech output data were considered in the context of phonological process analysis (PPA) and then through further analysis of segmental and prosodic aspects of MWU.

Intelligibility was measured through 66 unfamiliar adult listeners orthographically transcribing edited samples from each child of 10 SW, 5 imitated sentences and 5 samples of CS from T1 and T2.

Results

Psycholinguistic tasks revealed that the children had pervasive and complex speech processing difficulties. PPA based on traditional SW sampling failed to capture important aspects of children's speech; analysis of MWU revealed phonetic and prosodic features essential to describing and understanding children's development of "real talk"(Howard, 2007, p. 20). Intelligibility outcomes revealed listeners' recognition was better for MWU in three of the children; intelligibility was better for all children at T2.

Implications

Children with PSD benefit from thorough investigation of input and output speech processing skills; assessment of MWU is essential in capturing segmental and prosodic aspects of speech output to explain poor intelligibility and plan intervention.

Chapter One

Introduction and literature review

1.1 Introduction

Speech sound difficulties occur in around 15% of three-year-olds (Bowen, 2009) and the majority of these children will have fully intelligible speech, with or without intervention, by the time they go to school. However, there is a small group of children who present with severe and persisting difficulties which are slow to respond to intervention (Pascoe, Stackhouse, & Wells, 2006); these impact to such a degree that their speech is frequently unintelligible. The purpose of this study is to investigate the severe and persisting speech difficulties of four individual children and the effect of their atypical speech output on their intelligibility, as judged by a group of adult listeners. The investigation of each child was carried out at two points in time so that changes in speech processing skills and intelligibility could be measured. The study explored the children's speech production and intelligibility in different types of speech output; single words, imitated sentences and conversational speech.

The thesis is organised into eight chapters. In Chapters One and Two there is a review of the literature related to PSD and intelligibility, and the research questions to be investigated in the study. Chapter Three describes the methods used for the investigation. Chapters Four, Five, Six and Seven are individual case studies; each chapter describes the findings and also has a discussion related to that individual child. Chapter Eight presents a discussion of the overall themes which emerged from the case studies and then the limitations, and theoretical and clinical implications of the study.

A review was carried out to explore the literature relevant to the study of persisting speech difficulties and intelligibility in children, and to derive the research questions which would be examined in the course of the study. The areas of review described in this chapter are the definition and description of speech difficulties (also referred to as speech sound disorders, SSD), with a particular focus on those that are severe and persisting (persisting speech difficulties or PSD) and theoretical and clinical approaches to speech difficulties. In Chapter Two the review continues with a focus on speech production in the different contexts of single words and multi-word utterances, variability in speech production and intelligibility.

1.2 Speech difficulties: definition and description

Speech difficulties can be defined as:

> "any combination of difficulties with perception, articulation/motor production, and/or phonological representation of speech segments (consonants and vowels), phonotactics (syllable and word shapes), and prosody (lexical and grammatical tones, rhythm, stress and intonation) which may impact on speech intelligibility and acceptability" (McLeod et al, 2012, p. 1)

There are many descriptive terms for speech difficulties, for example, "speech sound disorder" (Bowen, 2009; Williams, McLeod, & McCauley, 2010); "developmental phonological disorders" (Rvachew & Brosseau-Lapre, 2012); "speech difficulties" (Stackhouse & Wells, 1997). These descriptions may reflect the theoretical perspectives of the writers, but also something of the cultural perspectives of the researchers and clinicians at a given time, so, for example, the terms "dyslalia" and "defective articulation" (Morley, 1972) have fallen out of use. Of the terms in current use, speech sound disorder (SSD) appears to be in the ascendancy in international literature. SSD may be transient or persisting and may vary in severity, sometimes needing intervention but sometimes resolving in early childhood. One group who may have ongoing and significant difficulties have been described as having "persisting speech difficulties" (PSD) (Pascoe et al., 2006).

1.3 Persisting speech difficulties (PSD): definition and description

Speech difficulties will resolve in the majority of children through developmental progress or intervention but there is a group who do not respond readily to intervention, defined by Wood and Scobbie (2003) as having "intractable speech disorders" (p. 1), by Shriberg, (1997a) as having "residual errors" (p. 106) and, as already mentioned, by Pascoe, Stackhouse and Wells (2006) as having "persisting speech difficulties" (PSD) (p. 2). The term persisting speech disorder is used in some of the literature; in this thesis the term persisting speech difficulties (PSD) will be used. Pascoe et al. (2006) make the case for the term PSD applying to children aged five and over, which is when children in the UK are required to manage the educational and social demands of formal schooling, in line with the critical age hypothesis espoused by Bishop and Adams (1990). This hypothesis proposes that children over the age of 5;6 years who have poor intelligibility are at much greater risk of poor educational outcomes. This issue about intelligibility is an important one because although speech sound production varies considerably in what may be considered the typical population of children and adults, after the age of 4;0 years speech is generally intelligible (Coplan & Gleason, 1988). Variability in the articulation of segments such as /s/ and /r/ (so called common clinical distortions, CCD, Shriberg, 1993) occur so frequently (7.9% of eight-year-olds, Wren, Roulstone, & Miller, 2012) that it is questionable whether "distortions" is the right term. They will usually not affect listeners' understanding of what is said, although observations from clinical practice suggest that such variability may impact on whether or not speech is judged to be acceptable. For children with PSD the concerns are about persisting difficulties in intelligibility and acceptability; intelligibility is defined as the listener's ability to recognise what the speaker has said and acceptability as the listener's subjective opinion of the quality of the speaker's speech production skills (Dagenais, Brown, & Moore, 2006).

1.3.1 The prevalence of speech difficulties in children

The estimates of the overall prevalence rates for speech difficulties described in the literature vary considerably (Law, Boyle, Harris, Harkness, & Nye, 2000). For example, Law et al. (2000) give a median figure of 5.95% for children aged up to sixteen. Broomfield and Dodd (2004) reported speech problems in 6.4% of children referred for assessment in a community health setting, although this population may be a different group to those identified through a broader screening process, since for these children a concern had been raised leading to referral. Bowen (2009) quotes that the Waisman phonology project estimates that 15% of three-year-olds have speech sound difficulties. Jessup, Ward, Cahill and Keating (2008), in a Tasmanian screening study, estimated 8.7% of children aged 5;4 to 6;10 had an isolated speech delay but Shriberg et al. (1998) estimated just 3.8% of six-year olds had speech-only difficulties.

1.3.2 The prevalence of persisting speech difficulties

Historically there have been a small number of large scale population studies that have explored the occurrence of speech difficulties at different ages, and in particular discuss prevalence in school-age children who may be considered to have PSD. In 1973 Peckham reported on the speech skills of children who were part of The National Child Development Study which was a longitudinal study of all children born in Great Britain during one week in March 1958. Based on teacher and GP estimates of intelligibility, and a brief speech assessment, in the group of over 1500 seven-year olds, 10-13% of children had some degree of speech difficulty. By the age of eleven this was reported to have dropped to around 4%. The study lacks detail and, as the author says, the children were not a homogenous group; the attempt to capture data on this scale was, however, brave and ambitious. Morley (1972), reported on a study of 944 children carried out in Newcastle in the 1950s suggesting that 11% of three-year olds were unintelligible but this had dropped to 1% by the age of six (p. 514). Shriberg et al., (1998), as previously mentioned, reported the prevalence of speech delay in six-year olds to be 3.8%, again based on a population of nearly 1500 children. The variability in the percentages reported in these studies undoubtedly reflects differences in how the data were collected, analysed and interpreted.

A more recent large scale study is the ALSPAC (Avon Longitudinal Study of Parents and Children, Wren et al., 2012) following the development of over 14,000 children born in 1991 and 1992 in an area of south-west England; 7,390 children attended for speech assessment at the age of eight with the express purpose of examining the occurrence of PSD. This study considered PSD to apply to children aged eight years or over, where children who have typical speech might be expected to be using the full range of speech sounds. The findings were that 991 children (13.41%) had speech errors, 582 (7.87%) of the total had difficulties with /s/ and/or /r/ (Common Clinical Distortions or CCD). The remaining 404 children were classified either as having PSD or non-PSD on the basis of PCC for the late-8[1] (Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997) and PCC-A, which does not count CCD as errors, with a cut off of 1.2 standard deviations above or below the mean; i.e. to meet the criteria for diagnosis of PSD children scored below -1.2 SD. Children who had speech errors but who scored above -1.2 S.D. were classified as non-PSD. These criteria resulted in 263 (3.55%) children being in the PSD group and 141 (1.9%) in the non-PSD group.

1.3.3 Risk factors for persisting speech difficulties

For the majority of children who have speech difficulties there is no known cause (Bowen, 2009), although clearly there are groups who have difficulty associated with physical, sensory or neurological conditions such as cleft palate, hearing impairment or cerebral palsy. Shriberg and colleagues (2010) have worked for several years to refine a

[1] Late-8 consonants are: /ʃ, θ, s, z, ð, l, r, ʒ/; in typical speech they are established later than other sounds, (Shriberg et al., 1997)

classification of speech difficulties, to describe categories of SSD, to link them to causal genetic and environmental factors, and to the processing systems affected. For example, speech delay-genetic, presenting in 56% of the speech delayed population, is caused by polygenic/environmental factors which affect the development of cognitive-linguistic processes. Shriberg et al. (2010) also identified a group who had SSD associated with otitis media with effusion, suggesting a link between a history of ear infections and ongoing speech difficulties. The clinical usefulness of the approach of Shriberg and colleagues has been questioned by Bowen (2009); also by Fox, Dodd and Howard (2002), not least because in their study of German children who had speech difficulties, they were not able to classify the children according to the categories suggested.

In this study, Fox et al. (2002) explored risk factors in a group of 65 children who had had speech difficulties compared with a control group who had typical speech. They cautiously concluded that a history of pre- or perinatal problems (such as prematurity), a positive family history of speech delay and prolonged use of a bottle might be linked with speech difficulties but, unlike Shriberg's group, they found no clear association with early hearing problems. They did not find that gender was a risk factor but this was unlike the majority of other studies (for example, Morley, 1972; Peckham, 1973; Wren et al., 2012) which report significantly higher rates of SSD in boys than girls (approximately twice as many) although the Wren et al. (2012) study found that this gender difference applied to the PSD and non-PSD groups but not to children with articulatory differences. The Wren et al. (2012) study also suggested that there was a significant difference in IQ between the children with PSD and non-PSD (mean 97.6 and 97.0 respectively) and the children with typical speech and CCD (mean 104.3 and 105.9 respectively), however, the large standard deviation scores for these groups suggested considerable overlap between them.

If it is the case that the evidence for causal factors is unclear, it is interesting to consider whether hypotheses concerning children's speech processing skills might indicate risk factors for PSD. The ALSPAC study (Wren et al., 2012) as already described suggested a combination of cognitive-linguistic and oro-motor deficits might underlie PSD. This suggestion of multiple deficits underlying PSD is supported by Pascoe et al. (2006) who took a psycholinguistic approach and described a speech processing model which has levels of input, stored representations and output. On the basis of their findings in detailed case studies which examined children's speech processing skills, these authors suggest that children with PSD "are thought to have multiple, and often severe, levels of breakdown throughout the system" (p. 10). The speech they produce is the obvious manifestation of impairments in input and representational skills, as well as in aspects of output planning and motor execution. Bowen (2009) lists "red flags for speech impairment" (p. 57) which include atypical or delayed canonical babbling; replacement of adult targets with glottal stops; initial consonant deletion; a limited number of consonants and/or vowels; backing; vowel errors; persistent final consonant deletion. It may be that these features in speech output together with risks identified such as family history of speech and language difficulties or early disruptions in hearing can alert clinicians to the possibility of PSD, especially in children who have poor intelligibility.

The ALSPAC study (Wren et al., 2012) made comparisons between PSD and non-PSD groups to examine whether there were features which distinguished between them. They concluded that the two groups were very similar on all measures (maternal education; IQ; number of boys vs. girls; non-word repetition) apart from diadochokinesis (DDK) tasks, where the non-PSD group scores were more similar to typical controls and the PSD and CCD groups were similar. On non-word repetition and IQ, the PSD and non-PSD groups were similar and the CCD group was like the typical group. This led the authors to hypothesise that the PSD and non-PSD groups might have some cognitive-linguistic deficits with weak phonological memory or processing capacity limitations and that the PSD and CCD groups had oro-motor difficulties. The PSD group, who had more severe speech difficulties, as measured by PPC-A and PCC-late 8, might have both cognitive-linguistic and oro-motor deficits meaning that they had more complex and persisting speech problems. (It is also possible, even likely, that the PSD and non-PSD groups represent the same type of children differing only in severity, related to oro-motor skills). The authors caution that the scale of the study means that some of the detail available with more finely graded identification of speech difficulties was lost, and that small scale studies would be important to complement their findings.

Preston and Edwards (2009) carried out a study with a group of 13 adolescents (aged 10-14 years) who had residual speech sound errors (RE) comparing them to age-matched controls, on rapid naming tests and diadochokinetic (DDK) rates. The speech delayed children (the RE group) were chosen because they had ongoing difficulties in production of rhotics but were also reported to have other segmental difficulties; these included difficulties in the production of alveolar and post-alveolar fricatives and affricates, and final consonant devoicing. The children were all referred by clinicians and, with the exception of one child, had been receiving speech therapy for between three and eleven years and had Percentage Consonant Correct scores (PCC) between 76% and 96%. The authors make the point that the group was likely to be skewed towards the more severe end of difficulty. (They also report that all the RE group had family members who had speech, language or literacy difficulties, suggesting strong genetic factors in this group). They found that the RE group were less accurate but not slower than controls on the DDK task, but were both less accurate and slower in the rapid naming task with multisyllable words but not single syllable letter names. The findings are explained in terms of multiple processing difficulties; DDK accuracy tapping into motor planning skills, and rapid naming of multisyllable words tapping into stored phonological representations and motor planning skills. They conclude that "it is unlikely that either a pure linguistic or pure motoric description will adequately characterize this population" (p. 315). This same group had been involved in a previously reported study (Preston & Edwards, 2007) which showed that the RE group had significantly weaker phonological processing skills than the control group (in spite of variability in test scores), supporting the supposition that they had difficulties throughout their speech processing systems.

One particular group of children at risk of PSD are those who have childhood apraxia of speech (CAS), referred to variously in the literature as CAS, developmental verbal dyspraxia (DVD) or developmental apraxia of speech (DAS) (Bernthal & Bankson, 2004). (See Ozanne, 2005 for a review of issues surrounding CAS). In this thesis the term CAS will be used unless reporting the work of other authors in which case their preferred term will be the descriptor. The diagnosis of CAS is not in itself a risk factor, but the processing difficulties underlying its clinical presentation mean that speech difficulties are likely to be persistent and resistant to intervention (Maassen, 2008). The American Speech-Language-Hearing Association (ASHA) position statement on CAS (ASHA, 2007), states that "The core impairment in planning and/or programming spatiotemporal parameters of movement sequences results in errors in speech sound production and prosody." (p. 1). Although some authors have suggested that children who have CAS do not have phonological awareness difficulties (for example, Broomfield & Dodd, 2004), the findings of individual case studies do not support this view (for example, Stackhouse & Snowling, 1992). Moriarty and Gillon (2006) in a study of three children aged 6-7 years, who met stringent

CAS diagnostic criteria, demonstrated that they had severe difficulties in a range of phonological awareness tasks and at the level of phonological representations. Other studies have reported a broad range of speech and language processing difficulties in children diagnosed with CAS. One such study, which also employed stringent CAS diagnostic criteria, was by Lewis, Freebairn, Hansen, Iyengar and Taylor (2004). They compared a group of ten children who had CAS with a group of fifteen children who had speech sound difficulties (S) and a group of fourteen who had speech and language (SL) difficulties, assessed at the ages of four and eight. At eight years of age the CAS group showed more deficits than either the S or SL groups in speech, receptive and expressive language skills, reading and spelling and performance IQ. The authors report that the group differences emerged over time and suggest that a diagnosis of CAS may be made most appropriately after the age of six years when these differences are more clearly defined. Although there were individual variations, there was evidence of broad-based cognitive, linguistic and motoric limitations in the CAS group. The children's speech had improved, particularly in single words, and they were "mostly intelligible" (p. 131) but showed difficulties in multisyllabic words and non-word repetition. They also comment that the speech of children in the CAS group showed qualitative differences to that of the other two groups, with "more unusual error patterns in conversational speech" (p. 131).

1.3.4 Summary: PSD

A small number of children (probably somewhere between 1% and 4%) show persisting difficulties with speech which are not confined to common articulatory differences with /s/ and /r/ but are qualitatively different, affecting segmental, structural and prosodic aspects of word production, and which may impact on intelligibility. Different authors have differed in specifying the age at which PSD may be used to characterise children's speech, but given the associated risk for poor literacy outcomes, Bishop and Adams's (1990) critical age of 5;6 years may not be too early. This may particularly apply to children who have received at least two years of intervention by this stage, when clinical observation suggests that most children's difficulties have been successfully treated. Children who have CAS may be a particular subgroup of PSD, although that is not specified in the literature, possibly because widespread use of the term PSD is relatively recent. The homogeneity of the two groups is not clear but studies suggest that children have difficulties in cognitive, linguistic and motoric processing skills whichever group is described. All studies describe different presentation and variability in individual children (for example, Lewis et al., 2004) suggesting that the description and explanation of PSD must include detailed single case studies in order to capture essential information about this particular group of children.

For the purposes of both research and clinical practice it is important to consider how children's speech difficulties have been described and what theoretical approaches underpin the conceptual frameworks used to analyse and explain those descriptions.

1.4 Theoretical and clinical approaches to the description of speech difficulties

There is currently an abundance of theoretical approaches to the description of speech difficulties, for example, nonlinear phonology (Bernhardt & Stoel-Gammon, 1994); articulatory phonology (Browman & Goldstein, 1987); the psycholinguistic framework (Stackhouse & Wells, 1997); cognitive phonology (Ball, 2003; Bybee, 2001). However, the influence of these approaches on clinical practice is variable and, observation suggests, dependent on the interest or expertise of individual practitioners. The approach that continues to dominate current practice is phonological process analysis, somewhat divorced from underlying theory (Grunwell, 1997) but used descriptively and analytically in varying degrees to conceptualise children's speech difficulties and to plan intervention. The next sections provide first an overview of phonological process analysis and then brief descriptions of other current approaches: nonlinear phonology; gestural (articulatory) phonology; the psycholinguistic approach; usage-based (cognitive) phonology.

1.4.1 Phonological process analysis

The 1980s brought a change to the assessment and description of children's speech in clinical practice with the application of phonological approaches to what had previously been conceptualised as difficulties with articulation (Fey, 1985); Edwards (1997) suggests that it was the publication of *Phonological Disability in Children* (Ingram, 1976) that brought linguistics to the attention of speech and language therapists in terms of the conceptualisation of speech difficulties. As Baker (2006) writes "phonology opened the door to a new way of thinking about children with unintelligible speech" (p. 157). Although there were a variety of theoretical models dating back to the 1960s and earlier, for example, generative phonology, Chomsky & Halle (1968) and distinctive feature analysis (McReynolds & Huston, 1971; Menyuk, 1968), it has been natural phonology which has had most clinical influence. This approach is rooted in the work of Stampe (1979) and expressed through the phonological processes approach to analysis, impacting on how clinicians assess and describe children's speech (Skahan, Watson, & Lof, 2007), certainly in English speaking countries of the world and often elsewhere (McLeod & Goldstein, 2012). This continues to be the case in spite of what Baker (2006) calls "an upsurge of theoretical applications to unintelligible speech" (p. 158) in recent years and phonological process analysis is the descriptive framework most commonly used in clinical practice.

Natural phonology is based on the principle that children are born with innate phonological processing skills which are universal and related to the articulatory and perceptual phonetic features of speech sounds (Grunwell, 1987; Hewlett, 1990; Miccio & Scarpino, 2008). Some sounds, it is argued, are easier to say than others (more natural) and so the child applies phonological processes (which are cognitive-linguistic rules) to difficult sounds or groups of sounds that make them easier to produce. Typically a process will affect a particular distinctive feature of voice, place, or manner, so, for example, in English fricatives are "more difficult" to say than plosives, so the child applies a stopping process to /s/, /f/ and /ʃ/ so that SUN is realised as [tʌn] and FISH as [pɪt]. Over time, as children's cognitive skills mature, they suppress these phonological processes and new sound classes emerge, with increasing ability to use a wider range of sounds and more complex word structures, thus increasing intelligibility (or more accurately, contrastiveness). (See Grunwell, 1987; Edwards, 1997; Baker, 2006 for further discussion). Children who have speech difficulties do not suppress phonological processes in the way that typically developing children do, and so continue to produce immature or "frozen" (Hewlett, 1985, p. 163) speech patterns.

The phonological/linguistic approach created a shift away from seeing speech difficulties as rooted in the child's inability to articulate speech sounds that mirror the adult model, and intervention focusing on each speech sound in turn (Grunwell, 1990), to analysing speech in terms of presenting patterns (phonological processes, see for example, Edwards, 1997) and targeting sound classes in treatment (Elbert, 1997; Williams, 2005). It also introduced the concept of systematic analysis of speech patterns (Stoel-Gammon, Stone-Goldman, & Glaspey, 2002). This crucially brought into focus the impact of the child's speech difficulties on successful or unsuccessful attempts to communicate meaning effectively, because when speech patterns mean that contrast is lost (for example, a child may say [dɔ] for DOOR, CORE, FOUR, SURE, TORE, CHORE and JAW) the intended word may also be unclear (Grunwell, 1990).

Grunwell (1997), in a chapter dedicated to natural phonology, describing its use by clinicians, suggests that the application of the phonological process approach is somewhat removed from the underlying theory, and that it is used "primarily as a descriptive device" (p. 47). The reason for this may lie in immediacy and accessibility for clinicians because the processes are:

> "more transparent and are thus more easily understood (than other approaches). Additionally they involve less formalism and require less academic preparation" (Edwards, 1997, p. 6)

The appeal for practitioners is easy to understand; the time available for assessment, description and treatment planning is limited (Bleile, 2002) and demand is high (Khan, 2002). Process analysis offers the means by which patterns can be identified and intervention targets set. It also offers a familiar developmental perspective; speech processes, by natural definition, result in simpler patterns like those seen in younger children (Grunwell, 1990; 1997), and an easy way to describe speech to colleagues (giving rise to such comments as "we are running a fronting group"). Almost any clinical perspective in common use can be slotted into a phonological process framework so whether the clinician adopts a developmentally incremental approach or targets based on maximum intelligibility (Hodson & Paden, 1991) or stimulability (Powell & Miccio, 1996), the starting point can be a list of processes identified in the child's speech.

Phonological processes can be sorted into two categories; those that affect word structure, for example, syllable deletion; cluster reduction; final consonant deletion; and those that affect segmental realisation, for example, velar fronting; stopping; gliding of liquids (Stoel-Gammon et al., 2002). There is also the occasional use of the terms such as "idiosyncratic patterns", by Hodson and Paden (1981) for example and "unusual/idiosyncratic processes" by Grunwell (1982). Stoel-Gammon et al. (2002) also describe a third category, that of consonant assimilation, where an anticipatory process means that a syllable-initial within-word (SIWI) consonant is harmonised with the syllable-final word-final (SFWF) consonant in the same word so, for example, DUCK is realised as [gʌk]. Grunwell (1987) describes consonant harmony (or assimilation) as a structural process where the place, voice or manner of one segment affects the realisation of another in close proximity. Certain types of contexts, and/or phonetic relationship (for example, the articulatory proximity of velar and alveolar places of articulation), seem more vulnerable to the effects of harmonisation. Ingram (1989) also uses the term assimilation to describe these processes, avoiding the term 'consonant harmony' and giving examples of vowel-to-vowel assimilation. Grunwell argues that assimilation is a structural process on the grounds that it is a simplification process which is predictable by structure i.e. the position of a particular segment in a word. However, there is another view, taken in this thesis, which suggests that instances of consonant harmony can be categorised as word level assimilatory errors (Bates & Watson, 2012), neither necessarily predictable nor affecting word structure in the way that consonant reduction, for example, does. These viewpoints illustrate that there are different perspectives on how to categorise phonological processes and that views on the nature and definition of processes have developed and changed over time. It is also the case that various proponents of the approach do not agree on how many processes there are that might fit into these broader categories, for example, Grunwell (1997) writes that Shriberg and Kwiatkowski (1980) describe 8 processes whereas Ingram (1981) describes 27, and there is therefore inevitably some variation in terminology. This leads to a suggestion that "in some accounts at least, the processes described push at the boundaries of naturalness" (Howard, 2012, personal communication). This variation in terminology may not be important within a given community of professionals, so for example, UK speech and language therapists may use Grunwell's terms and US speech-language pathologists may refer to Hodson. However, there is at least the potential for confusion in data sharing, although, as Edwards (1997) remarks all the approaches "share the goal of discovering the phonological processes underlying children's sound errors" (p. 6). There is also a view that approaches generally only list processes which are based on the patterns seen in typical speech development and so may not accommodate processes seen in disordered speech (Grunwell, 1995). Indeed, theories of natural phonology were founded upon observations of the emergence of typical speech, not those of clinical populations (Miccio & Scarpino, 2008), and so might limit the way that clinicians describe and conceptualise speech difficulties.

This concern was highlighted by Grunwell (1990), who cautioned that the approach may be somewhat reductionist (see also Lof, 2002) because it sets out in a predetermined way the patterns that might occur, does not easily accommodate "unusual and disordered data" (p. 11) and does not assess the impact of the speech difficulties on the child's overall communication skills. Grunwell (1995) makes this point more generally by commenting that the approach does not describe the consequences of processes, only that they are present. This is not least because, as already noted, processes are based on patterns observed in typical speech development (Miccio & Powell, 2010). Harris and Cottam (1985) remark that clinicians draw on "practical experience to extrapolate phonological generalisations...without having to couch them in formal notation" (p. 62). This may certainly relate to clinical expediency but perhaps also increases the danger of reductionism. The most popular assessment in the UK (Joffe & Pring, 2008) is the South Tyneside Assessment of Phonology (Armstrong & Ainley, 1988) a single word naming test. It is quick and easy to administer, and may be useful for pattern recognition in children who present with speech delay, but its ease of use may feed into this reductionist approach. Butcher (1989) suggested that the adoption of a phonological process approach in assessing children's speech has led to its indiscriminate use and an assumption that all children who have speech difficulties have a language disorder, because difficulties are ascribed to a cognitive-linguistic level. Furthermore, as he describes, phonology assessment (and therefore description) generally focuses on production of consonants, ignoring vowels and suprasegmental features. He suggests that this is because this better suits phonological process analysis, and also that vowels and prosodic information are more difficult for clinicians to transcribe or describe. This point about the difficulties in the perceptual analysis of vowels is explored in detail by Howard and Heselwood (2013) who nevertheless advocate the importance of this perceptual analysis because it "engages us more fully with the data" (p. 72) which means that the significance of details and patterns can be assessed. Butcher (1989) also makes the point that focusing only on consonant data means that information essential to explaining problems in intelligibility will not be captured. This is because children may present with developmentally delayed or disordered vowel patterns (Reynolds, 2013) or that there may be interactions between consonants and vowels, "context-conditioned error patterns" (Bates, Watson, & Scobbie, 2013, p. 288) which are not evident through consonant analysis alone.

The reductionism of the approach is further seen in goal setting for intervention, not only because of a potentially narrow data set from assessment but because the processes are at a cognitive-linguistic level and therefore the intervention will also be focused at that level, which in its truest form means confronting children with their errors through minimal pairs, creating "cognitive dissonance" (Howell & Dean, 1983). In his original work, Stampe (1979) suggested that children's representations of words were the same as those of adults and that their production patterns reflected articulatory rather than perceptual constraints. This view was supported by Hewlett (1990) who reported that research indicates that perception in typically developing two-year olds is established for the majority of targets in the adult system. However, he also reported that research suggests that this may not be true for all children with speech difficulties. This was supported through findings of later studies; Rvachew, Rafaat and Martin (1999) and Lof (1996) examined phoneme perception and stimulability in children who had speech difficulties, and showed dissociation between input and output. Furthermore, there seemed to be both child-specific and phoneme-specific differences with some children able to perceive sounds they could not say, and say sounds they could not perceive in discrimination tasks. For example, Lof (1996) described how in his study five children who had used [f] for / θ / were able to copy / θ / but none were able to perceive it. Findings such as these disprove the suggestion that children's perception skills are necessarily the same as those of mature speakers. This view is supported by Munson, Edwards and Beckman (2005) who reviewed the literature concerning differences in adults and children in skills related to phonological knowledge, including speech perception. They report that typically developing children do not have the same proficiency as adults, and that children with atypical speech sound development are less proficient than their typically developing peers. Rvachew and Brosseau-Lapre´ (2012) also describe how speech perception skills develop during childhood, and furthermore suggest that there is an association between these skills and vocabulary size.

McGregor and Schwartz (1992), presenting a single case study of a four-year old who had speech difficulties, suggested that models of speech production need to accommodate for individual children having different input and output representations for different phonemes. For this reason, intervention typically includes aspects of both perception and production (Stoel-Gammon et al., 2002) which reflects both the dissociation between the original theory (proposing intact perceptual skills) and current practice, but also the successful sharing of later findings indicting that children's input skills may need consideration. However, interestingly, Edwards (2012) states that intervention:

> 'generally focuses almost exclusively on the production of correct sounds (although ear training may be involved) without considering other levels of phonological processing' (p. 4)

This would seem to contradict the views of authors such as Stoel-Gammon et al (2002) and Rvachew and colleagues (Rvachew & Grawburg, 2006; Rvachew, Nowak, & Cloutier, 2004) but the matter of different processing levels is another source of discussion in the literature, as is the application of the concept of phonological processes to all children who have speech difficulties.

Stoel-Gammon et al. (2002) mention that phonological processes may not be suitable for describing the speech of every child, in particular: "children with errors on single phonemes or for those who produce distortions" (p. 5). This would suggest that analysis and description of a different kind would apply to children who have articulatory difficulties (CCD) or motor speech disorders such as dysarthria. This leads to another important issue which applies to other phonological approaches, not only natural phonology. Stampe (1979) rooted phonological process theory in "mental operations" which although resulting from and in articulatory constraints, were nevertheless cognitive-linguistic (i.e. language based) and inherently divorced from the phonetic/articulatory output level. This would imply, as already discussed, that speech difficulties are by nature linguistic. Grunwell (1987) stresses the need to distinguish between (linguistic) phonological disorders ("an abnormal or inadequate or disorganised system of sound patterns evidenced by deviations in spoken language" p. 272) and phonetic disorders ("usually associated with some organic deficiency", p. 272, such as cleft palate). She states that these may co-occur (in children who have a cleft palate, for example) but emphasises the importance of differential diagnosis. However, phonetic and phonological levels of processing may not be as clearly distinct as Grunwell (and others) suggest, and may in fact develop in an interdependent way (Bernhardt & Stemberger, 1998; Bernhardt, Stemberger, & Charest, 2010; Hewlett, 1990). Grunwell herself later says that there are interactions between levels of phonological organisation and knowledge, phonetic organisation and planning and articulatory execution (Grunwell, 1990), although she also wrote that most children with speech difficulties do not have any problems with the production of individual speech sounds (Grunwell, 1985a). This is supported by evidence that some children use speech sounds in one context but not another apparently similar one; an example given by Dodd, Holm, Crosbie and Hua (2005) is a child saying [kwæk] for CRACK but [wæk] for QUACK (p. 42). However, Hewlett (1985) expresses the view that both in typical and atypical speech development, phonological processes are a product of children's immature motor skills. He proposes that an intact phonological processing system (as described by Stampe, 1979) responds to articulatory limitations by establishing patterns that children can produce. This view of interactions between phonological and articulatory levels is shared by Fey (1992) who says that children who are not able to produce speech sounds in a typical way "necessarily develop a phonology that differs in important ways from the adult phonology" (p. 228). Williams (2002) reflects that some phonological processes appear to be causally related to phonetic factors, citing assimilation as one such process. In children who have severe or persisting speech difficulties it can be hypothesised that interactions between phonetic or articulatory constraints might interact with the representational or phonological level and this might also impact on the development of acoustic-perceptual skills (Bernhardt et al., 2010). Scobbie (1998), using data collected during a study using electropalatography (EPG) showing evidence of covert speech contrasts describes the phonetic and phonological systems as working in "tandem" (p. 12) for speech development.

Discussions about the interaction between phonological and phonetic levels of processing are enhanced by evidence from studies of children's speech development in languages other than English. Much of the published material available explores data from monolingual, English speaking children, however, there is a growing body of work based on examination of typical and atypical speech in other languages (McLeod & Goldstein, 2012). Ingram (1997) described a study carried out by Bortolini, Ingram and Dykstra (1993) comparing a group of typical and phonologically impaired Italian speaking children. They found that /v/, a segment that emerges relatively late in English but early in Italian, was also acquired early by the speech impaired group. Ingram (2008) reported that other studies in Greek, Swedish and Turkish show similar patterns, with the phonetic inventories of children with speech difficulties reflecting those of their linguistic peers who had typical speech development. This was also the conclusion of Bortolini and Leonard (1991), who in a study also of Italian children reported that although the children shared some patterns found "universally" (p. 8) in disordered speech, the children's phonetic inventories and processes reflected that they were Italian speakers and influenced by their language environment. These observations are compatible with the usage-based approach to phonology, where the frequency of the speech input directly shapes the child's storage and the output patterns of utterances (Bybee, 2001; Tomasello, 2001). So and Dodd (1994) drew similar conclusions in a study of Cantonese-speaking children with speech difficulties; this was also seen in a study of Spanish-speaking children carried out by Yavas and Lamprecht (1988). These studies suggest that children's speech difficulties are

> "influenced by both the phonetic characteristics of the phonemes being acquired as well as the types of sounds in the ambient language that might serve as plausible substitutes" (Bortolini & Leonard, 1991, p. 1)

and therefore that "difficulties in speech acquisition have a phonological component" (Ingram, 2008, p. 638). This highlighting of the interaction of phonetic frequency with the phonological system draws into question the notion of "difficult sounds"; perhaps in intervention an approach which includes focused listening and familiarisation (Rees, 2001) with targets in different word contexts might be a useful strategy, drawing on the importance of the frequency of input in speech development. Ingram (1997) does not take the view that speech difficulties involve only a cognitive-linguistic level (for example, discussing the impact of late maturation of laryngeal control on children's realisation of voicing distinctions) but that the child's processing system responds as best it can to accommodate both phonological and phonetic demands and constraints. There is a theoretically stronger view that the child's phonological system develops as a system of abstractions based on the phonetic and motor behaviours of infancy (Vihman & Velleman, 2000). The individual perceptual and motoric skills of the child shape the phonology; phonological processes are thus an outward manifestation of children's underlying processing strengths or difficulties.

1.4.2 Nonlinear phonology

Discussions about the relationship between phonology and phonetics, and speech perception skills stem from the recognition that the production of speech is the result of interactions of different levels of processing. Nonlinear phonology, developed in the 1990s (Bernhardt, 1992a & 1992b; Bernhardt & Stoel-Gammon, 1994) presents a hierarchical framework for assessment and intervention which allows the analysis of children's speech patterns in terms of whole words, prosodic and syllabic levels and segmental feature-based descriptions. Target setting may be based on, for example, ensuring that the child uses all basic word and syllable shapes or expanding the segmental inventory by introducing a new distinctive feature, for example, [+consonantal]/[+sonorant] (liquids). The approach has been used to present elegant descriptions of children's speech difficulties (see, for example, Bernhardt, Stemburger & Major, 2006) but it has not had any major impact on clinical practice in the UK, possibly because its perceived or actual presentation is complex (unlike familiar phonological process analysis).

1.4.3 Gestural phonology

Gestural phonology (Kent, 1992a) (also called articulatory phonology (Browman & Goldstein, 1992) has been used as a descriptive framework for SSD in research studies but appears to have had even less impact on clinical practice than nonlinear phonology. Hodson and Jardine (2009) wrote an accessible paper describing how gestural phonology could be used for analysis and treatment planning. The study was based on Jarrod, a child with unintelligible speech who was the focus of a special issue of *Advances in Speech-Language Pathology* (Holm & Crosbie, 2006). Hodson and Jardine describe how the principles of gestural phonology explain speech difficulties in terms of problems in the shaping of the vocal tract (degrees of constriction and tongue shape for example) and in movement types (the degree of force needed and the timing of movements). In analysing Jarrod's data the authors suggest that his intelligibility difficulties can be explained through difficulties in managing the degree of force needed for fricative production, and in timing of movements between gestures resulting in "undershooting" (p. 131) of target sounds. Although the arguments are compelling, their treatment recommendations lack specificity in relation to gestural phonology. Bahr (2005), in a study examining articulatory gestures in children with CAS, phonological disorder and typical speech, recommends that speech assessment includes a consideration of the complexity of required articulatory gestures for syllable and word production. She found that her gesture-based assessment did not definitively aid differential diagnosis but that children with CAS seemed to have more difficulty than children with phonological disorder in gestural coordination. Consequently she suggests that, for example, clinicians might not target nasal segments in the early stages of treatment because such gestural combinations (i.e. raising the velum plus constriction of the oral cavity) are more difficult. This seems to conflict with clinical experience and published case studies where even children who have the most severe levels of impairment are usually successful in the production of nasal segments (see for example, case studies by Pascoe, Stackhouse & Wells, 2006; Grunwell, 1985b). Therefore, while it may be useful for clinicians to have an appreciation of the concept of gestural phonology in relation to speech development, and for this to be considered in the explanation of children's speech difficulties, the application of this approach to intervention in clinical practice is currently not sufficiently defined for it to be widely adopted. This view is compatible with that of Lieshout and Goldstein (2008) who state that

> "Gestural accounts of speech production ... will need to demonstrate that their models provide an economical and efficient way to explain known phenomena in normal and disordered speech...." (p. 475)

A core concept from the perspective of gestural phonology is that speech output emerges from pre-linguistic babble which is shaped (and constrained) by the movements of the infant's immature motor system, "deriving speech from nonspeech" (MacNeilage & Davis, 2000, p. 285). Speech development and the maturation and refinement of motor skills are inextricably linked. In adults, speech is realised through "synchronised articulatory gestures, or functional groupings of gestures" (Bates, Watson, & Scobbie, 2013, p. 290); in multi-word utterances the resulting overlapping of movements leads to coarticulation (Browman & Goldstein, 1986). Coarticulation is therefore "a natural consequence of the interactions between gestures in speech" (Hodson & Jardine, 2009, p. 123). In the phases of the development of an adult system, children present with immature output as a consequence of immature motor systems. As motor sequences become more sophisticated, phonetic variability in output may reflect immature control of the timing of gestures (Kent, 1992). The gestural phonology account does not seek to disregard other dimensions involved in speech output, for example, acoustic and linguistic factors. However, if the development of mature speech is dependent on the "refinement, differentiation and coordination of gestures" (Kent, 1992, p. 262), difficulties in subsystems supporting these processes could underlie the speech presentation of children who have PSD.

1.4.4 Psycholinguistic approach

The psycholinguistic approach (Baker, Croot, McLeod, & Paul, 2001; Pascoe, Stackhouse, & Wells, 2005; Stackhouse, Pascoe, & Gardner, 2006; Stackhouse & Wells, 1993) sets out a framework for exploring, describing and explaining children's speech difficulties; it also allows for an assessment of skills integral to the links between speech sound production and literacy development (Stackhouse & Wells, 1997). Although the approach might appear to have its origins in "box-and-arrow" models (see Baker et al, 2001), its application in clinical use with children has been largely through the work of Stackhouse and Wells (1997) which is demonstrably rooted in focused observation and practice. As Howard (2010) describes:

> "the focus of assessment shifts radically from the traditional focus on speech production, to investigate the child's strengths and weaknesses across the whole range of processes which contribute to speech perception, storage and production" (p. 349)

This approach is underpinned by the concept of levels of processing, and that children may have difficulties in, for example, discrimination of speech sounds or imitation of non words, but essentially, it also encourages clinicians to think of a whole speech processing system and the relationships between different aspects of it. This "whole system" approach allows comparison between children in terms of profiles of processing strengths and difficulties but moreover recognises the heterogeneity of children and the value of individual profiles in intervention. This enables the clinician to move beyond broad diagnostic categorisation (which may have a place and a purpose) to understanding the processing difficulties that a particular child may have which lead to problems in speech production. Importantly, it also encourages consideration of the child's speech perception and discrimination skills, i.e. input processing as well as the presenting, and more immediately obvious, difficulties in speech output. It is compatible with phonological, phonetic or perceptual explanations and supports principled decision-making about intervention.

The model proposed by Stackhouse and Wells (1997) (see appendix 1.1) addresses the levels of processing for the perception and recognition of speech, the storage of lexical items and the processes involved in speech output. This will be summarised in detail since it forms the basis of part of this current study (for full description see Stackhouse and Wells, 1997). The peripheral levels of input involve hearing the speech signal and then recognising it as speech (as opposed to other types of sound). The next process is that of phonological recognition, which is assumed to be attuned to the child's own language or languages; if the speech is recognised it can then be matched to stored lexical representations. If the input is novel material in the form of new words or non-words, and therefore not recognised, the child accesses phonetic discrimination skills. This is described as an off-line process i.e. it does not employ the automatic processing available for familiar material. Phonetic discrimination involves parsing or segmenting the input and then identifying the constituent segments or syllables. This involves recognition of language specific elements at a sub-lexical level. At this stage the child (or adult, who might employ this route if dealing with novel material) has possibly accessed sufficient information to be able to repeat what has been heard, as in a non-word repetition task for example. Phonetic discrimination may also be employed in the processing of familiar words spoken in an unfamiliar accent where the child's phonological representation of the heard words is not sufficient for recognition.

At a representational level, lexical items are established and stored; the essential components of lexical storage are described as a phonological representation, a semantic representation and a motor programme; other constituent parts will include grammatical representations and later, orthographic representations. The phonological representation contains "enough information to identify the word uniquely" (Stackhouse & Wells, 1997, p. 158) but is likely to be underspecified to allow the flexibility needed for identification of variable forms of individual words. For example, the same word may vary according to speaker, accent and phonetic context but must still be identified as that one word. The semantic representation consists of multiple features and associations concerning the meaning of the word. The motor programme (or program) contains "a series of gestural targets for the articulators" (Stackhouse & Wells, 1997, p. 162), a blueprint for how to produce the word, descriptions compatible with those used in gestural phonology (Kent, 1992; Browman & Goldstein, 1992) as previously outlined in section 1.4.3. It is suggested that in naming activities or conversational speech the semantic representation drives access to the motor programme and that the phonological representation, essential for word recognition, is not activated.

Speech output is derived from the motor programme for known words; the production of novel words requires activation of the motor programming level, another off-line component of the system, most commonly assessed through non-word repetition tasks (Stackhouse & Wells, 1997, p. 163). The construction of new motor programmes is described as the process of selection of component segments and syllables (possibly onsets and rimes) which are then assembled and mapped as a new motor programme. Established and novel motor programmes are realised through motor planning processes. The motor planning level, sometimes referred to as phonological assembly (Dodd, 1995), is where the retrieved gestures required for the output of the intended utterance are assembled in sequential order. The overall prosodic shape is put in place and the phonetic contexts of units (words or high frequency utterances) are accommodated. It is at this level that the phenomenon of "slip of the tongue" has its source, where segments are exchanged or replaced, for example, the target CAR PARK realised as PAR CARK. The peripheral level of speech output is motor execution which involves the movements of the physical structures of the vocal tract.

Assessment of the peripheral aspects of speech output may be through activities such as non-speech oro-motor tasks. The motor execution level is assessed through diadochokinesis (DDK) tasks. These tasks involve the production of repeated sequences of segments (Stackhouse & Wells, 1997) e.g. [p] or syllables e.g. [pə pə pə], [pə tə kə] which are assessed for consistency, speed and accuracy. Deficits in performance are attributed to motor execution difficulties although if children are able to articulate target segments it is feasible that there are also impairments at the level of motor planning.

The psycholinguistic approach offers the potential to explain the SSD of children within a framework which provides both breadth and depth, complementing the rich descriptive linguistic data which may be collected in the course of investigating children's speech. The breadth of the approach is in the encompassing of both input and output processing; the depth is in the different levels from peripheral acoustic and phonetic processing to underlying cognitive-linguistic representations. Interactions between different levels of processing can be accommodated. The focus is shifted away from constrained diagnostic categories (which may have some value and purpose, but may equally direct intervention towards approaches unhelpful for some children) towards individual profiles of processing strengths and difficulties. Together with a detailed description of the child's error patterns at a linguistic level, these may prove more sensitive to describing and meeting the treatment needs of children who have PSD.

1.4.5 Usage-based approach

The usage-based approach to speech development (Bybee, 2001, 2010), sometimes referred to as the cognitive approach (Ball, 2003; Sosa & Bybee, 2008) conceptualises the language system as the product of interactions between the child and the environment. Language use shapes both the form and content of speech sound systems; form follows function. The child establishes lexical representations which are strengthened through repeated use. This strengthening takes the form of increasingly detailed acoustic information based on multiple exemplars of individual words and phrases which enables children to extrapolate categorical phonetic information (Rvachew & Brosseau-Lapre, 2012). Frequency of input plays an essential part in language learning (Ellis, 2002), allowing the child to recognise patterns and make associations between items. It is also proposed that every exemplar is stored, and the number of exemplars and how recently they were heard plays a role in their strength (Pierrehumbert, 2003).

Exemplars may be at the level of single words but high-frequency multi-word utterances may also be stored as units (Bybee, 2002). These "lexical chunks" (Ellis, 2002, p. 155) may be subject to phonetic reduction with the drive towards more neutral or understated articulatory gestures (Bybee 2006). This also facilitates the smooth and fluent realisation of multi-word utterances with coarticulation and between-word speech processes (Bybee, 2001). Thus, the usage-based approach is compatible with that of gestural phonology (Newton, 2012). In adults it may be the case that much of their language output "consists of piecing together the ready-made units appropriate for a particular situation" (Nattinger, 1980, p. 341). Furthermore, this process of exemplar development continues into adult life, supporting lexical expansion beyond the traditionally described developmental timeframe (Ferguson & Farwell, 1975; Rvachew & Brosseau-Lapre, 2012).

The application of a usage-based approach to phonology for children who have speech difficulties was outlined by Ball (2003). He suggested that deficits could be described in terms of poorly defined lexical networks or limited lexical storage. He also suggested that there may be "incorrect storage due to perceptual breakdown or due to articulatory difficulty (or a combination of the two)" (p. 66). Whilst this may be the case, this description might apply to many theoretical approaches, so does not perhaps provide any advantages over other explanatory frameworks. However, in the context of what Pierrehumbert (2003) describes as "the terrible complexity of phonetic patterns" (p. 117), going on to say that "the problem of phonological acquisition is far worse than generally supposed" (*ibid*), the impact of having difficulties as described by Ball (2003) begins to have more weight. If indeed the process of speech development depends on children's ability to establish exemplars, and from those create pattern-based networks, any disturbances to the speech processing system will create vulnerabilities. The more severe the limitations, whether in input or output skills, the more severe their impact is likely to be. Sosa and Bybee (2008) suggest that the clinical application of the approach makes analysis of the individual patterns shown by children an essential element of assessment and intervention. The focus is on the links between the child's phonology and lexical development, and the role of frequency, and by implication, meaning.

Chapter One has focused on the review of the definition and description of speech difficulties (also referred to as speech sound disorders, SSD), with a particular focus on those that are severe and persisting (persisting speech disorders or PSD) and theoretical and clinical approaches to speech difficulties. The literature review continues in Chapter Two.

Chapter Two

Literature review

2.1 Introduction

Chapter Two continues the literature review with a focus on speech production in the different contexts of single words and multi-word utterances, variability in speech production and intelligibility. At the end of this chapter are the research questions for the study which emerged from the literature review.

First, a note on terminology: "connected speech" is used inconsistently in the literature. In this thesis the term "multi-word utterance" (MWU) or "multi-word speech" is used to refer to any speech output which is longer than one word, unless a particular author uses the term "connected speech". However, in reference to between-word speech processes, the term "connected speech processes" (CSP) is used. The term "conversational speech" (CS) refers to speech samples collected in conversations between the author and study children, unless, again, when referring to the term when used by a particular author.

2.2 Speech production in different contexts

In this section consideration will be given to some of the factors that influence speech production in different types of output (i.e. single words and multi-word utterances). The focus will be on the role of frequency and reduction in typical speech; the production of typical and atypical multi-word utterances and how different types of speech output are assessed.

2.2.1 The role of frequency and reduction in speech production

It is evident that mature adult speakers, and children as learners of speech, produce words in combination with other words from a very early stage of development. This process of speaking in "words and phrases" is described in this extract:

> "In learning to talk, children must gain knowledge of the phonological forms of words and phrases of their native language and must learn the articulatory and phonatory movements needed to produce words and phrases in an adult-like manner" (Stoel-Gammon & Sosa, 2007, p. 238)

This process of language learning in order to produce "words and phrases in an adult-like manner" involves children paying attention to the features of the language that they hear, for example, phonological, prosodic, syntactic and pragmatic information, which enables them to establish stored linguistic representations for both understanding and production (Ellis, 2002). These representations are established at word and phrase level (Bybee, 2002) and are incrementally strengthened by the effects of frequency (Bybee, 2001) allowing the abstraction of knowledge and patterns, and the construction of a network of associations. These are built on individual experience (Bybee, 2002), driven by lexical development (Stoel-Gammon & Sosa, 2007) and shaped by shared cultural and social expectations within a linguistic community (Wray & Perkins, 2000). Frequency effects on the production of speech gradually support the establishment of formulaic "chunks" of language which can be understood and produced more fluently than novel utterances (Bybee, 2001). Indeed, young children may learn some chunks as a whole and only later disentangle the individual words (Stemberger, 1988).

> "Smooth talkers use many formulas in their speech, such as recurrent sequences of verbal behaviour, whether conventional or idiosyncratic, which are sequentially and hierarchically organized" (Ellis, 2002, p. 156)

(For a broader description of the development and purposes of formulaic language see, for example, Wray and Perkins, 2000).

These high frequency formulaic utterances are greatly susceptible to "reduction" (Shockey, 2003, p. 2), or "massive reduction" (Johnson, 2004, p. 1) where the word is realised in a way that involves significant differences in segments (and syllables) in comparison to the citation form (that is, the production of the single word in formal speech). These reductions, resulting from cutbacks ("undershoots" Shockey, 2003, P. 12) in vocal tract movement (Lindblom, 1990), are established and stored as "single neuromotor units" (Bybee, 2002, p. 17) which facilitates the automatic production of frequently used utterances. Johnson (2004) suggests that word form storage is based on exemplars which have "both auditory and articulatory representations" (p. 50), accommodating the range of possible variants of each individual token with sufficient phonetic information both for recognition and production. This approach is compatible both with single word and utterance level language.

Descriptions of reduction might seem to suggest that children first learn words in their citation forms and then as word combinations develop, over time learn how to combine words together into integrated chunks. However, this is not what the authors of these descriptions are implying. Young children produce high frequency multi-word utterances that are formulaic or stereotypical in nature (Howard, Wells, & Local, 2008) which appear to be recognised and produced as single units. It may be that these are only analysed at word level much later, possibly as children acquire the skill of segmenting phonemes within words. Indeed, there is some debate about what constitutes a word since some high-frequency combinations, for example, "don't know"; "going to", might be construed as single entities (Bybee, 2001).

One further but important point is that reduction is not random but bound by (at least) two factors related to intelligibility. The first is interactional (Lindblom, 1990; 1996) where the speaker "makes a running estimate of the listener's needs...on a moment to moment basis" (1996, p. 1687); Lindblom suggests that speakers adjust the amount of articulatory effort needed in a given situation along a hyper-/hypo-speech continuum (the H & H theory). The second factor is phonetic in that there appear to be key elements in the segmental and/or syllabic structure of a word which must be retained for recognition, what Heselwood, Bray and Crookston (1995) describe as "an acceptable limit" (p. 127). Johnson (2004), in analysing reduction in adult speech, gives the example of variants of the word "until" from the citation form /ʌntɪl/ to the massively reduced /tə/ and makes the point that all productions retain the segment /t/; this suggests that the "t-ness" of "until" is non-negotiable. Both interactional and phonetic factors have implications for young children who are learning to talk, who will acquire these skills over time, and learn which variants can or must occur in which contexts but at a recognisable rate (i.e. being intelligible by the age of four, Coplan and Gleason, 1988) and for children who have speech difficulties, who may not. The interaction between speech sound difficulties and speech reduction may lead to children not realising essential segments which allow for listener recognition of speech output thus reducing intelligibility (Speake, Howard, & Vance, 2011).

2.2.2 The production of multi-word utterances

In order to produce "words and phrases in an adult-like manner" (Stoel-Gammon & Sosa, 2007), children must learn how individual words are produced in different linguistic contexts; multi-word utterances are more than sequences of single words. The phonological and phonetic demands are qualitatively different (Howard et al., 2008). This is described by Cruttenden (2001):

> "If the word is admitted as an abstract linguistic unit, it is important to note the differences which may exist between its concrete realisation when said (often artificially) in isolation, and those when, in connected speech, it is subject to the pressures of its sound environment" (p. 278)

Utterances are bound together within a prosodic framework of lexical and supra-lexical features (Stackhouse, Vance, Pascoe, & Wells, 2007); at a single word level (lexical) this is mainly through stress patterns and in multi-word utterances (supra-lexical) it is particularly through intonation, which both delineates groups of words and is used to signal meaning within linguistic and pragmatic frameworks. Within and between utterances, changes at word boundaries ensure smoothness and cohesion, meaning that production of the same target may be different in single words and multi-word utterances, accommodating to the phonetic requirements of nearby speech sounds. Farnetani and Recasens (2010) describe the production of connected speech in terms of coarticulation where "the movements of different articulators...overlap in time and interact with each other" (p. 316). Coarticulation at word boundaries results in changes which are referred to as connected speech or between-word processes (Newton & Wells, 2002; Newton, 2012) or word juncture (Howard et al., 2008; Pascoe et al., 2006).

Word juncture is described as open or close (after Sprigg, 1957) and broadly serves two purposes; firstly, to keep words apart and distinct (open juncture) or for emphasis, marked, for example, by pauses or glottal stops (Wells, 1994). Open juncture may also result when typically occurring close juncture processes such as elision or assimilation (see below) are not used (Newton, 2012). Secondly, word juncture functions to "glue the utterance together into a cohesive entity" (close juncture), (Stackhouse & Wells, 1997, p. 226), close juncture involves different types of phonetic (and phonological) adjustments. These may result in the occurrence of connected speech processes which are essentially simplifications which accommodate to the articulatory features of particular segments which are in close proximity to each other. In English these are:

1) Elision: segments are omitted as in FIRST PART realised as /fɜs ˈpɑt/

2) Assimilation: word-final segments anticipate the same place of articulation as the initial consonant of the following word (typically bilabial or velar), for example, BAT AND BALL realised as [ˈbæʔ m̩ ˈbɔl]

3) Liaison: word-final vowels are linked to the following word-initial vowels by a glide or liquid, for example: FAR OUT (non-rhotic) realised as [fɑʴ ˈaʊt]; BLOW OUT realised as [bləʊʷ ˈaʊt]; SEE OUT realised [siʲ ˈaʊt]

4) Coalescence: a word-final segment combines with initial segment of the following word to form a segment which has features of both, for example, MISS YOU realised as [ˈmɪʃu]; NEED YOU realised as [ˈniʤu]

A particular form of elision is recognised in a process labelled "schwa absorption" (Shockey, 2003, p. 22), the schwa vowel may be elided with a neighbouring consonant taking on the property of the syllable, operating both within and across word boundaries. Shockey (2003) gives the example of "and they" being realised in a highly reduced form as [n̩ ɛi] (p. 23) and also describes how schwa may be subject to assimilation with another vowel, for example, 'to have' realised as [tʰ æv]. Some segments are more liable to change than others so, for example, again, Shockey (2003) describes a continuum of vulnerability with /t/, /ð/, and /ə/ as "incredibly vulnerable" and /f/, /m/, /ʃ/, /ʧ/ and /ʤ/ being "practically invulnerable" (p. 15). This must be important when considering the intelligibility of children who have speech difficulties, since, with exception of /m/, those segments deemed "practically invulnerable" are frequently problematic for those children.

There is very little literature exploring word juncture in either typical or clinical child populations (Newton & Wells, 2002); it seems likely that there is a developmental progression towards adult-like multi-word utterances and that this may be protracted or possibly different in children with speech difficulties, as in the development of single words, but this has not been unequivocally established. Newton and Wells (1999) in a study of typical children aged 3.6 to 7 years-old found that their participants used similar types and proportions of between-word processes as adults do with 75 to 80% of possible instances of assimilation, elision and liaison being realised in this way. This raised questions about whether close juncture occurred from the beginning of phrase development (i.e. it simply happened) or if it became established during the first two years of connected utterance use (and under the age of 3;6).

Stemberger (1988) reported a longitudinal study of his daughter's early speech (up to the age of 3) focusing on emerging multi-word utterances; he described resyllabification of word-final consonants occurring before a vowel, for example, "get up" realised as [da . tʌp] (p. 42), vowel deletion, assimilation or deletion of vulnerable segments and consonant harmony or reduplication. Significantly, he commented that these processes were not found in adult English (although do occur in other languages) and implied their transitory and changing nature. Given the variability and amount of change documented in other aspects of speech development in very young children (Sosa & Stoel-Gammon, 2006) these findings are perhaps unsurprising.

Developmental changes were explored by Thompson and Howard (2007) who reported on the speech of three 2-year-olds and three 3-year-olds. They found that open juncture was more common in the younger children, although elision was already present by 2;0 and that other forms of juncture emerged over time. There was a significant change from a preference for open juncture in 2-year-olds (although there were individual differences in the balance between the open and close types) to close juncture in the older group where three-quarters of possible occurrences were realised with adult-type processes. The 2-year olds also used assimilation but this was subject to variation, with bilabial articulatory patterns most likely to be realised in that way. They concluded that word juncture behaviour emerges over time but that there were differences between individual children. They also describe how the 2-year-old child with the greatest percentage of open juncture made frequent use of glottal stops at word boundaries. Interestingly, they also comment on the occurrence of non-adult assimilation and resyllabification in the 2-year-olds as described by Stemberger (1988) but this was not found in the data for 3-year-olds.

Newton and Wells, (2002), carried out a study of a typical child, CW, between the ages of 2;4 and 3;4 to examine whether CSP were evident at an earlier stage. CW had a different word boundary pattern to that reported by Thompson and Howard in that he showed a preference for close juncture, including assimilation, elision and liaison from the age of 2;4. However, they also found that at the beginning of the study CW produced non-adult forms such as glottal stops at word boundaries and for a time between 2;7 and 2;9 he used more open juncture than previously, although close juncture was more common. After the age of 2;10 his patterns were like those of older children and adults. The authors make the point that open juncture may be phonetically demanding; in word boundary positions where, for example, elision may be used to achieve close juncture, the segmental sequence involved in an open juncture realisation will require (at least) three consecutively realised consonants. Both studies report early use of /j/ and /w/ liaison (from the two-word stage) but /r/ was later. Newton and Wells (2002) suggest that /j/ and /w/ liaison result from phonetic factors (i.e. the articulatory output of moving from one vowel shape to another) and /r/ liaison reflects phonological learning. These possibly different causal relationships lead the authors to caution against the use of the term connected speech processes because this implies a phonological rather than phonetic basis for word juncture behaviours. A useful distinction can be made between phonetics, the production or articulation of speech sounds (Stackhouse & Wells 1997), and phonology, the linguistic organisation and use of speech sounds to "convey meaning" (ibid, p.5) which has helped to shape the conceptualisation and understanding of the nature of different types of speech difficulties. However, the research literature also suggests that making this distinction is not without its difficulties (Hewlett, 1985; Grunwell, 1987), and acknowledging the phonetic underpinning of emergent phonological organisation provides a valuable perspective on speech development (Sosa & Bybee, 2008; Vihman and Velleman, 2000).

The discussion about whether word juncture behaviours are phonetically or phonologically driven is a topic of debate. All languages have word boundary accommodations in multi-word utterances although the nature of these changes is different in different languages (Howard et al., 2008). For example, assimilation processes may be regressive as in English, where word onset affects the production of the coda of the previous word, or the opposite where the final segment of the first word changes the onset of the next. This might suggest that the phonetic drive for simplification is moderated and manifested through language-specific phonologically specified processes. Farnetani and Recasens (2010) carried out a review of the current evidence concerning the roles of phonetics and phonology in coarticulation with a particular focus on connected speech processes. They acknowledge the complexities of the mechanisms of speech output, and the theoretical and empirical explanations for these processes. They express the view that a gestural approach to speech output may be best placed to provide an account of what is seen in connected speech, although also state that no model to date can explain all aspects of speech output, particularly when comparing features in different languages.

Thus far, the focus has been on speech in typically developing children which leads to exploration of studies of word juncture in children who have difficulties with speech production.

2.2.3 Multi-word speech production in children who have speech difficulties

Studies of word juncture behaviours, limited in number in children with typically developing speech, are even fewer in relation to children with speech difficulties; the few that are published show some interesting results. Wells (1994) presented a single case study of a child called Zoe (aged 5;11). Zoe's speech was characterised by slow and disjointed utterances with word boundaries (and sometimes within-word syllable boundaries in turn-end words) produced with open juncture. This pattern is very different to that reported in children with typical speech. Although the reasons for this are not certain, the author suggests that it could be a reflection of motor difficulties, with Zoe using a slower speech rate as a strategy to aid intelligibility or could even be the result of the application of speech therapy intervention techniques. Howard (2007) explored connected speech production in six young people (aged 9;5 to 16;3); four had speech difficulties associated with cleft palate, one had dysarthria related to Worster-Drought Syndrome and the last had no identified organic condition. The study used both instrumental (electropalatographic, EPG) and perceptual speech analysis to examine multi-word outputs. Although the participants all demonstrated some typical close juncture at word boundaries, there was significant variability within and between speakers and atypical features were noted in both segmental and prosodic aspects of speech. The author describes both hyperelision and hyperarticulation effects, and in this study and that of Wells, the data suggest that the children are struggling to manage the demands of the multi-word utterance level of output. As Wells (1994) describes:

> "There is a developmental tension between the demands of paradigmatic accuracy, i.e. the need to signal lexical meaning in an intelligible way, and the demands of syntagmatic fluency, i.e. the need to realize phrases and sentences as cohesive wholes" (p. 2)

Klein and Lui-Shea (2009) investigated what they referred to as "between word simplification patterns" (p. 17) in four boys (age 4;0 to 5;5) who had speech sound disorders, focusing on assimilation and elision occurring at word boundaries. They found that, although subject to individual variation, the most frequently occurring pattern was that of final consonant deletion, either in single segments between vowels or as part of adjacent consonant sequences. They comment that although this is seen in the speech of adults and more so in typical speech development, these children deleted a much wider range of speech sounds with greater frequency (and, it is suggested, persisting beyond the usual time span expected for the development of adult-like speech patterns).

Newton (2012) explored the between-word processes of three 11 to 12-year-old children who had speech difficulties, taking an approach theoretically underpinned by usage-based phonology. Newton used both perceptual and electropalatographic (EPG) assessment and reported that although all three children produced some adult-like word boundary behaviours, their output also showed evidence of atypical patterns. These included glottal stop replacement of SFWF consonant clusters (also reported by Newton and Wells, 2002, as occurring in the speech of a typically developing 2-year-old), described by Newton as the result of extreme lenition. It is explained in the context of "effort minimisation" (p. 724); the children's response to the complex phonetic environments of word boundaries was to reduce the gestural/articulatory demands and replace the adult targets with "the most minimal type of closure available to the speaker" (p. 723). Newton suggests that this simplification of output is the same as happens in the connected speech of typical speakers but in an atypically extreme form, or "hyperlenition" (p. 724). In another recent study exploring connected speech output, Howard (2013) reports her findings on the speech of two children (JO and SB) who had PSD in association with a history of cleft palate. Both children had difficulties with word juncture but presented with very different patterns; JO showed a preference for adult-like close juncture and SB for less typical open juncture. The perceptual impact of these different behaviours was that JO who used more adult juncture was less intelligible; his close juncture was associated with greater segmental and structural omission (hyperelision). By contrast, SB was more intelligible but his speech was perceptually unusual. Importantly, both of these studies highlight the differences in multi-word speech behaviours shown by individual children, suggesting that children respond differently to the challenges which may be inherent in multi-word speech production. This is also the case at a single word level, but the complexities of multi-word utterances may lead to an even greater range of possible individual solutions.

Although the evidence base about word juncture in children who have speech difficulties is not extensive, these studies indicate that they find the management of the demands of word boundaries challenging; given problems in managing other complex phonetic and phonological sequences, this is not particularly surprising. However, given the evidence from adult speech, and the emerging picture of word juncture in typical development, what is perhaps surprising is that assessments for children who have speech difficulties continue to focus largely (and sometimes only) on single word production (Howard, 2007) which may be "misleading and ultimately unhelpful" (Howard, 2004b, p. 416). It is interesting to consider the different types of utterances are used in assessment, and how this is reported in the literature.

2.2.4 Speech sampling types used in assessment

As already noted, the stimuli used most often in assessment of children who have speech difficulties are single words (Howard, 2007; Morrison & Shriberg, 1992; Pascoe et al., 2006; Skahan et al., 2007) involving picture naming (often of high frequency, easily-pictured nouns) and yet the production of speech sounds, and intelligibility may be different in different types of utterance (Barnes, Roberts, Long, Martin et al., 2009; Howard et al., 2008). This may mean that difficulties in intelligibility are unrecognised or underestimated (Faircloth & Faircloth, 1970; Morrison & Shriberg, 1992). Multi-word utterances also enable assessment of prosodic aspects of speech and observations of interaction between different levels of the child's linguistic functioning (Bernhardt & Holdgrafer, 2001; Rvachew & Brosseau-Lapre, 2012).

It is widely accepted that "conversational speech is the most ecologically valid context (i.e. it is what speakers most often do)" (Flipsen, Hammer, & Yost, 2005, p. 308). However, the analysis of conversational speech is not necessarily quick or easy, and because the segmental (and lexical) content is not controlled as in a single word assessment, some aspects of the child's speech patterns may be missed (particularly relevant when completing a phonological process analysis, less so when analysing "real talk" Howard (2007, p. 20). In terms of repeated measures, a SW test allows a straightforward comparison of speech production over time (Bernhardt & Holdgrafer, 2001). Where children have intelligibility difficulties, the assessor may find description and analysis of speech problematic, because the targets are not known (Kwiatkowski & Shriberg, 1992). There are ways of possibly reducing the impact of this by using more defined tasks such as picture description, or sentence repetition and these are reported in the literature, although, where multi-word utterances are assessed, conversational speech is the most common method of sampling (Morrison & Shriberg, 1992).

From the child's perspective, conversational speech may not present such overt difficulties as a naming test in that he or she has "control over topic and content" (Morrison & Shriberg, 1992, p. 262) and, to a degree, the articulatory demands through choice of lexical items, thus avoiding particular segmental difficulties (Masterson, Bernhardt, & Hofheinz, 2005; Wolk & Meisler, 1998). The sound patterns of single word tests are designed (with greater or lesser success) to sample, for example, consonant clusters and multisyllabic words which may occur in much lower numbers in the child's own speech. Morrison and

Shriberg (1992) compared PCC in words elicited in a single word articulation test with words used in the conversational speech of 61 children (age range 3-6 years) who had speech delays. They found that the test words included a much greater number of two and three-syllable words with "considerably more difficult structural contexts" (p. 263). In terms of segmental content, the vowels /ei/, /æ/ and /ɚ/ occurred with significantly more frequency in testing whereas /ɑɪ/ (because of the frequency of the lexical item 'I') was more frequent in conversational speech. They also found that there was a higher rate of occurrence of simplification processes in conversational speech. Somewhat different findings were described in the study by Masterson et al. (2005) who compared the production patterns of 20 children with phonological impairments in SW and conversational speech. Importantly they used single words which were partially tailored to individual children, depending on their responses to an initial screening set; this was designed to increase the sensitivity of the SW assessment. The study found that SW sampling resulted in the production of more CVCVC words, and more velars, affricates and liquids than conversational speech. Interestingly they do not allude to connected speech processes but describe difficulties in transcribing word-final stops particularly in CVC words in conversation; this was dealt with by not counting word-final deletions, glottal stops or voicing differences as errors. Although not described as such, this may have resulted in an accommodation to any word juncture processes shown by the children because SFWF alveolar and velar plosives are commonly affected by between-word assimilation or elision. Once this was done, SW and conversational speech PCC "accuracy", initially significantly better in SW, was then more similar in both types of sample across the group as a whole. However, the data suggested that there were some (relatively small) differences in sampling for individual children (some favouring SW and some conversational speech). This finding is different to that of Wolk and Meisler (1998) who report that in their study of 13 boys aged 4;2 to 5;11 years, the PCC in single word naming was significantly poorer than that in conversational speech (although they too report some individual differences). They suggest that this is because the single words used were more complex both structurally and segmentally than words produced by the children in conversational speech.

The issues of how speech production in SW might be different to that in multi-word utterances, although occasionally mentioned in the assessment sampling literature (for example; "traditional articulation tests have not adequately taken into account the influence of phonetic context" Wolk & Meisler, 1998, p. 292) seem to be almost entirely ignored. It seems surprising that in even quite recently developed assessments the authors do not at least mention these differences to aid assessors in their evaluation and to add potentially useful information to the analysis. For example, in a study of the speech of 684 English speaking, typically developing children, Dodd et al. (2005) examined the production of a set of 14 lexical items, comparing the realisation of each word in SW and MWU (using a humorous picture description task). Production errors were identified and classified into age-appropriate, delayed and unusual patterns; these were found to be different with more errors in MWU. They examined the speech of children from the ages of 36 to 83 months and found that these differences resolved over time and by 77 months all the children's words were 97-100% the same. This task was taken from the DEAP assessment (Dodd, Hua, Crosbie, Holm, & Ozanne, 2002) where one of the calculations is the percentage of SW vs. connected speech agreement; this can then be converted into a standard score. All the items were high-frequency nouns (for example, frog; snake; toothbrush); no mention is made of any connected speech processes that might legitimately occur and how these might be scored. This raises an issue relating to wider interpretation of these noun data at least, with an inherent implication that words should be produced in exactly the same way regardless of phonetic context. This is clearly not the case. Bernhardt and Holdgrafer (2001) make this point in a paper outlining the issues of sampling techniques for the analysis of children's speech saying that:

> "The mere context of the phrase (with its coarticulation, rate and stress timing) may increase the likelihood of segment deletion, substitution, or assimilation in any word" (p. 23)

They suggest that SW, conversational speech and sentence imitation may all be used in order to sample enough reliable data, and the use of selective supplementary data is necessary to explore particular patterns and for children who show variability in production.

Sentence imitation as a sampling method has been examined in the literature. For example, Johnson, Weston and Bain (2004) explored the PCC scores in sentence imitation and single words in a group of 21 children with speech difficulties aged 4;0 to 6;11. In a rigorously designed study they controlled sentences for age-appropriate vocabulary, syntax and speech sound distribution (this latter aspect is reminiscent of the sentence imitation used in the speech assessment of children who have cleft palate described by Sell, Harding, & Grunwell (1994)). They reported that in the group as a whole there were no significant differences between the sampling types. However, 12 of the individual participants had scores that were better on one or other of the sampling types and a small number of children showed quite different responses to the materials either in terms of their speech more closely matching the adult model (which may be positive indicator) or in finding the imitation task too difficult. One of their conclusions is that assessment should be sensitive to the needs of individual children and, as suggested by Bernhardt and Holdgrafer (2001), a variety of sampling types will best present a complete profile of the child's speech. Rvachew and Brosseau-Lapre (2012) review the literature concerning sampling methods and also highlight the different responses of individual children in imitative tasks; they suggest that children who have had intervention may particularly produce speech in imitation that is better than spontaneous output; for this reason they recommend using "spontaneous conversation to elicit the speech sample" (p. 140).

Masterson et al. (2005) make the important point that differences between sampling types may be significant statistically but not necessarily clinically, in that the targets chosen for intervention for the group in their study were the same for the majority of children whether based on single words or conversational speech. This clinical versus statistical significance may not present difficulties if it is the case that children's speech difficulties can be entirely described, explained and remediated through use, for example, of a phonological process framework. However, as suggested for example by Howard (2004b, 2007), this may not be the case for children who have severe and persisting speech difficulties where atypical segmental and prosodic patterns which are not evident in single words may be identified in multi-word utterances. Intelligibility is not simply or only about the severity of segmental differences as measured through PCC (although there is clearly a relationship between them). Using a range of sampling types will enable an analysis that identifies all the factors that are important in understanding and explaining the intelligibility of an individual child.

A commonly occurring theme throughout the literature is the variable performance both between individual children and also that within the speech production of individuals. This may be related to sampling type but there are a multitude of other factors that may influence how consistently children's speech is produced.

2.3 Variability in speech

Variability in speech production is a feature of typical development in young children which lessens over time (Holm, Crosbie & Dodd, 2007; McLeod & Hewett, 2008); "a source of noise that is reduced by maturational influences" (Forrest, Elbert & Dinnsen, 2000, p. 520). However, phonetic variability is also a feature of adult speech, influenced by linguistic, pragmatic and articulatory context and subject to the conventions of the language being spoken (Shockey, 2003). Variability might be expected in typical speech when comparing the same words produced in different linguistic and phonetic environments (Holm et al., 2007) but Miller (1992), when discussing a clinical population of adults with dyspraxia, suggests that variability is best considered in the context of token to token comparison in the same context, for example, repeated productions of a single word. This view is shared by Holm et al (2007), who differentiate between "normal variability" and "atypical inconsistency" (p. 468), stating that repeatedly different realisations with different types of error is symptomatic of SSD.

Variability may be positive; Bernhardt and Stemberger (1998) comment that "in times of change...variability can arise" (p. 257); this variability typically results in productions that more closely match adult targets. This could be therefore be termed progressive variability. Segmental analysis of what the child is producing is therefore clinically important since variation between the adult target and one other segment may be an indication of positive change (Grunwell, 1992) (a "behavioural indication of reorganization" Tyler & Lewis, 2005, p. 246) but the variable use of two or more phones which do not include the adult target may not be positive (Grunwell, 1987).

Progressive variability may be manifested in different ways; for example, a target segment may be lexically influenced so that /k/ may be realised as [k] in CAR but [t] CAT segments may be affected by their position in a word so that /k/ is realised as a velar plosive word-finally but an alveolar plosive in word-initial position. These kinds of variability may be predictable, so from a listener perspective (once the realisation is known) are perhaps unlikely to affect intelligibility. However, token to token variability, when children have different productions of the same word, may present listeners with more difficulty in understanding what has been said.

As already described, the term "inconsistency" is also used, with the term "inconsistent phonological disorder" (IPD) introduced as a diagnostic category (Dodd & Bradford, 2000; Dodd, 1995). Variability has also been examined in relation to childhood apraxia of speech (CAS), also called developmental verbal dyspraxia (DVD), with changes to repeated productions of the same word and increasing errors in longer utterances being possible diagnostic markers (Davis, Jacks, & Marquardt, 2005; Davis, Jakielski & Marquardt, 1998).

There is some discussion in the literature about the sources of variability. Forrest et al. (2000) suggest that it is associated with underspecification of phonological representations; increases in linguistic loading may increase variability (Tyler, Williams, & Lewis, 2006), with an effect of complexity in terms of word structure (and interactions with lexical, semantic and syntactic processing). This raises some interesting issues about whether variability in the speech of children who have speech difficulties is any different to that seen in children who have typical speech development. In a usage-based approach to speech development (Bybee, 2001), the ability to manage variability in perception and production in single words and multi-word utterances must be hallmarks of the emergent system so that children learn to manage complexity as necessary. Given that, over time, the speech difficulties of the majority of children resolve through intervention and/or maturation it may be that the variability seen in SSD mirrors the protracted development of the speech processing system as a whole.

There are two main schools of thought about whether variability (inconsistency) is diagnostically significant, with accompanying implications for intervention. One approach is that espoused by Dodd and colleagues (Dodd & Bradford, 2000; Dodd, 1995; Dodd, Holm, Crosbie, & McIntosh, 2006, Bradford & Dodd, 1996) also described by Forrest and colleagues (Forrest et al., 2000). Their view is that this group of children with IPD, who present with multiple speech inconsistencies, do not respond to intervention in the same way as children who have consistent errors. For example, Forrest et al report on a study of 10 children aged 3;4 to 4;6, half of whom had inconsistent speech, matched with the other half who did not. They reported a much better rate of progress for the consistent group; however, as they acknowledge, the percentile scores of the inconsistent group was significantly lower than the other group at the start of the study. Dodd and colleagues describe the inconsistent group as having difficulties with phonological assembly (for a description of this see, for example, Stackhouse & Wells, 1997) and assess for this using a criterion of 40% variability on a set of 25 words; this can be assessed using the DEAP (Dodd et al., 2002). The focus of treatment is on establishing consistent (not necessarily accurate) production of 50 high frequency words for each child which then provides a more stable platform for further intervention.

A different approach is that taken by Tyler and colleagues (Tyler & Lewis, 2005; Tyler et al., 2006; Tyler, Lewis, & Welch, 2003) in their study of 40 children with speech difficulties, they separated the 10 most and 10 least consistent of the group and carried out the same kind of intervention with both groups. They found that both sets of children responded equally well to intervention with a steady pace of change in terms of PCC. However, the children who showed most variability also had significantly lower PCC at the start of the study (38.6%, S.D. 6.8 vs. 73.9%, S.D. 11.13). Not only did all the children's PCC improve, the number of variable productions showed a corresponding decrease throughout and after treatment. Furthermore, the authors quote a study by Iserman (2001) which suggests that individual phonemes differ in terms of their vulnerability to variable production. Those segments which have the highest and lowest individual PCC scores (and are most stable) are least subject to variability; later developing sounds more likely to be inconsistently realised. They also report that /t, k, g, f, v, s, z, j/ are subject to high levels of inconsistency in children who have speech disorders. Given the developmentally early use of /t/ and /j/ it does seem possible that variable realisations of these segments may be the result of different factors (perhaps to do with vulnerability to typical reduction in multi-word utterances).

The reconciliation of these approaches may lie in the views of Rvachew and Brosseau-Lapre´ (2012) who suggest that the diagnosis of "Inconsistent Deviant Phonological Disorder" may well have validity for individual children at a given point in time but that there is no evidence as yet that this represents a stable diagnostic subgroup over time. It may be that as Rvachew, Chiang and Evans (2007) report, severity and age are the important factors, with a decrease in unusual and structural errors as children get older. Variability may be a product of the relative maturity of the child's speech processing system.

2.4 Intelligibility

Intelligibility has been defined as "that aspect of oral speech-language output that allows a listener to understand what a speaker is saying" (Carney, 1986, p. 47) and "the product of a series of interactive processes" (De Bodt, Hernandez-Diaz Huici, & Van De Heyning, 2002, p. 284). Thus by definition intelligibility is an outcome of a communicative interchange between a speaker and listener or listeners although the term "comprehensibility" is probably more accurately used to describe the understanding of speech in interaction (Yorkston, Strand, & Kennedy, 1996). In learning to talk children must learn how to manage the verbal and non-verbal processes needed to effect successful communication; one aspect of this is how to produce speech with sufficient segmental and prosodic accuracy to be intelligible. Most children will accomplish this by the age of four (Coplan & Gleason, 1988; Chin, Tsai, & Gao, 2003) but children who have difficulty with the production of speech sounds may not achieve this (Gordon-Brannan & Hodson, 2000; Weston & Shriberg, 1992) and for some children who have persisting speech difficulties (PSD), problems in being understood will also persist (Pascoe et al., 2006).

In spite of intelligibility being the "*sine qua non* of spoken language" (Kent, 1992b, p. 9), there is no universally agreed way of measuring it, and reliability and validity are difficult to establish (Pascoe et al., 2006). Furthermore, although measures may provide an indication of the severity of the impact of speech difficulties, they do not provide any explanation of why or how intelligibility is compromised in individual cases (Weismer, Kent, Hodge, & Martin, 1988; Metz & Schiavetti, 1994). Clinically this is important because understanding what makes the speech of an individual more or less intelligible should guide decision making in intervention (Hodson & Paden, 1991; Dodd & Bradford, 2000). It is also essential in research terms in developing models that can explain both typical and atypical speech.

Intelligibility in children who have developmental speech difficulties (and indeed in children who have typical speech) has received relatively little attention in published literature (Hustad, 2012); searches reveal that the majority of paediatric studies have been done with the deaf population (for example, Monsen, 1983; Chin et al., 2003; Peng, Spencer & Tomblin, 2004). There are also a number of studies of intelligibility in children who have cleft palate (see Whitehill, 2002, for a review). This is perhaps unsurprising given that these groups are both clearly identifiable through diagnosis of an organic condition and have a long history of multidisciplinary and particularly medical involvement. With national programmes for cochlear implants and regionally organised, hospital-based services for cleft palate, the drive for positive outcomes to support and justify investment has understandably and rightly meant that intelligibility has been a focus for these groups. This has not been the case for other developmental speech and language difficulties which are typically identified later, do not fit a defined diagnostic category and do not usually involve medical practitioners. However, even given the robust approach taken to intelligibility measurement in deafness and cleft palate, evidence of work giving detailed phonetic analysis that might explain why children are unintelligible, is still limited (Pascoe et al., 2006; Whitehill, 2002).

2.4.1 The measurement of intelligibility

Intelligibility is measured in several ways (although as suggested by Gordon-Brannan and Hodson (2000) most clinicians rely on "impressionistic estimates", p. 142). Measurements are made through the following techniques:

- Listener responses to speech (single words or multi-word utterances); typically listeners are asked to write down what the speaker has said (open-set method) (Gotzke, Hodge, & Daniels, 2003; Hustad, 2006a, 2008; Khwaileh & Flipsen, 2010) or are given a choice of possible words, controlled for segmental content so that target realisations and minimally paired choices based on "substitution errors" are available (closed-set method) (for example, Chin, Finnegan, & Chung, 2001)
- Rating on a numeric scale (for example, Van Lierde, De Bodt, Van Borsel, Wuyts, & Van Cauwenberge, 2002)
- Indirectly, through the correlation of intelligibility with severity (for example, Percentage Consonants Correct (PCC) Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997a)

Use of both open-set and closed-set stimuli is reported in the clinical literature; studies with adults who have dysarthria have found that the scores in open-set testing are lower than those using the closed set method (Yorkston & Beukelman, 1978, 1980) but that the individual ranking for intelligibility is the same. Kent, Weismer, Kent and Rosenbek (1989) suggest that these differences are not a concern and this may well be the case as long as the same method is employed for retesting individuals. This was the recommendation of Vigouroux and Miller (2006) who found in a study of people who had dysarthria related to

Parkinson's disease, that the relationship between ranking results of open-set and closed-set task was not consistent. They suggested that closed-set tasks might provide a more sensitive measure for speakers with severe impairments but that for mild to moderately impaired speakers the open-set method might be more sensitive and more closely related to rating of connected speech intelligibility.

There are published (but not norm-referenced) intelligibility assessments but they are not commonly used in the UK. For example, the Children's Speech Intelligibility Measure (CSIM; Wilcox & Morris, 1999) and The Beginner's Intelligibility Test (BIT; Osberger, Robbins, Todd, & Riley, 1994). Both involve recording children repeating either single words (CSIM) or sentences (BIT) which are then played to two unfamiliar listeners who are asked to write down what the child has said. The targets in these word identification tasks are known so an intelligibility percentage score can be calculated and also repeated as a measure of progress.

Hodge and Daniels (2007) developed this approach, with a software based intelligibility measure (Test of Children's Speech Plus, TOCS+) which involves listeners in trying to understand children's imitated single words (in both open and closed sets) and sentences, using a computer to record the child's speech and listeners' responses. Initially the authors compared children who had cleft palate with a typically developing group (Hodge & Gotzke, 2007) but later presented data on children with SSD compared with a typical group (Hodge & Gotzke, 2008). These examples also included a 100 word sample of spontaneous speech. The software produces an intelligibility measure derived from the percentage of matches between the responses and targets. This assessment allows for phonetic analysis at a single word level in the closed set task by presenting listeners with the option of choosing between minimally paired words (for example, "cape/tape") or orthographically recording their own response; they can also record whether the response was "clear" or "distorted". The responses of up to three listeners can be compared to give a word-by-word analysis of the child's speech, and output patterns can be identified. However, caution in the use of minimal pairs is advised by Weismer (2008), who suggests that there are biases inherent to choices based on lexical frequency and the fact that "test items and their foils do not allow equal opportunities for errors in either direction" (p. 572).

Gordon-Brannan and Hodson (2000) linked intelligibility measurement with phonological process analysis in a study using 48 typical and speech delayed children aged 4;0 to 5;6.

The children were divided by the researchers into four groups of 12, based on the intelligibility of their spontaneous speech. Samples of imitated single words and sentences, and spontaneous speech were recorded; four adult listeners carried out four activities: identifying single words in a closed set task; orthographic transcription of imitated sentences; orthographic transcription of spontaneous speech; rating the intelligibility of the spontaneous speech on a 7-point Likert scale ranging from 1 (in effect, unintelligible) to 7 (intelligible). Using the same samples, the authors transcribed "phonological deviations" reported to be based on patterns identified in the Assessment of Phonological Processes Revised (APP-R, Hodson, 1986) but not described in the paper. The study demonstrated significant correlations between the measures and also suggests that the children's intelligibility was closely related to their phonological output skills. However, the authors emphasise the wide range of individual variations and that intelligibility may be affected by many factors including contextual and prosodic aspects of communication.

Rating scales are designed for listeners to judge children's intelligibility and assign a numerical score to this judgement. These scales may be direct magnitude estimation, where the listener estimates the percentage of the utterance understood, or interval scales where the listener assigns a number corresponding to intelligibility, for example, 1 for completely intelligible and 7 for completely unintelligible. Van Lierde et al. (2002), for example, used a rating scale for the speech of children who had cleft palate comparing the effects of cleft type on intelligibility and resonance; the scale had 4 points (intelligibility that was normal; slightly impaired; moderately impaired; severely impaired). Interval rating scales would seem to have an advantage of being quick and easy to administer and score (Ertmer, 2010; Pascoe et al., 2006) but their reliability and validity have been criticised (Samar & Metz, 1991) because listeners tend to assign different values at either end of the scale (Whitehill, 2002) and there is not necessarily good interrater reliability at mid points (Samar & Metz, 1988). This is particularly important in measures over time for the same child who might see different clinicians or in comparing the severity of different children. With poor interrater reliability and validity, asking even two or three listeners to judge a child's intelligibility could not be guaranteed to result in robust outcomes. Given that word identification measures reveal that the intelligibility of individual children varies between listeners (Speake, Stackhouse, & Pascoe, 2012) it is essential that opinions are sought from more than one source; if rating scales are the preferred option in particular circumstances (due to ease of administration) the literature raises questions about how this might be done in a reliable and valid way.

This question has been addressed by McLeod, Harrison, & McCormack, (2012) in the development of the Intelligibility in Context Scale (ICS). The authors report a trial of the ICS with parents of 120 children (aged 4-5 years), 109 with speech delay and 11 with typical speech development. The ICS is a measure which requires parents to rate their child's intelligibility with a range of seven familiar and unfamiliar people using a 5 point Likert scale (the child is understood: never; rarely; sometimes; usually; always). The ICS ratings were compared with an assessment of severity for each child, based on PCC and PVC calculated from the DEAP (Dodd et al., 2002) and found to be moderately correlated. Ratings distinguished between the group who had speech delay and those who did not; children who had speech delay were most likely to be intelligible to parents, immediate family, friends and teachers and less likely to be intelligible to unfamiliar people. The authors concluded that the ICS was a reliable, valid and sensitive measure of "functional intelligibility" (p. 654) but suggested that further research with a larger population was needed. The immediate advantage of the ICS is that it presents the experience of seven different listeners through a single exercise, and thereby captures the child's intelligibility potential across a range of communicative contexts. It would have been helpful to know what instructions were given to parents in terms of how to complete the rating scales because there may be a difference in parents' estimates of intelligibility and, for example, the teachers' actual experience. An aim of any future development of the ICS might be to find out if this is the case.

The judgement of intelligibility by different types of listeners has been explored in the literature. Familiarity with the speaker is an advantage so, for example, mothers understand more speech than fathers (Flipsen, 1995). Experience of speech difficulties also seems to be an advantage; In a study of the intelligibility an adult who had severe hearing impairment, James (1995) found that fourth year speech and language therapy students understood more speech than their first year counterparts. She concluded that this was because they had greater experience in listening to disordered speech. Bridges (1991) found that speech and language therapists understood more than inexperienced listeners when judging the intelligibility of an alaryngeal speaker. However, these assumptions about experience (as opposed to familiarity) may not hold true. In another study of listeners understanding the speech of a deaf child, Klimacka, Patterson and Patterson (2001) found that one of their inexperienced listeners understood more than three of the experienced listeners. This variability in individual responses (underpinned, presumably, by individual factors such as attention and perception) was highlighted by Ellis and Beltyukova (2008) in a study designed to train listeners in judging the intelligibility of children with hearing impairment; after an initial test, the listeners received (in different written and auditory forms) familiarisation training and/or feedback on their judgements leading to a final post-training test measuring their understanding of single words. All the listeners improved in their judgements although overall intelligibility scores remained low and there was considerable variability in the responses. This variability has been found in other studies; for example, McHenry (2011), examined the conversational intelligibility of three adults who had dysarthria as judged by 228 unfamiliar adults. The participants had mean percentage scores of 64%, 60% and 62% respectively but the range of listener responses for each speaker was very wide (13%-99%, 17%-100% and 4%-89%). The majority of studies have used adult listeners but Speake et al. (2012) recruited a group of volunteer peers to assess the intelligibility of two 10-year-old children with PSD using a write-down task for single words, imitated sentences and conversational speech; outcomes for child listeners showed similar ranges of intelligibility as studies using adult listeners. Ertmer (2011) points out that by the age of nine children are able to understand how to use a rating scale and manage age appropriate write-down tasks.

Intelligibility may also be measured indirectly through its relationship with severity, so, for example, if a child has a low score for PCC, intelligibility will also be compromised; it has been suggested that where PCC is less than 60%, the speaker is assessed as essentially unintelligible (Gordon-Brannan, 1994). There is also an issue when children's speech is very difficult to understand because calculation of PCC may not be possible when the target is not known (Pascoe et al., 2006). However, although it is broadly the case that low segmental accuracy will negatively impact on intelligibility, as seen with the comparison between performance on the DEAP tasks and the ICS (McLeod et al., 2012) this correlation may only be moderate. A study by Barnes et al. (2009) looked at intelligibility in boys who had Fragile X syndrome (FXS) and Down syndrome (DS) to explore speech accuracy and intelligibility and reached conclusions demonstrating a disconnection between these two measures. The boys with FXS had higher scores of segmental accuracy as measured by Percentage Consonants Correct (PCC) and Proportion of Whole-Word Proximity than those with DS, and had fewer phonological processes but their intelligibility outcomes were similar. The authors suggest that prosodic factors (such as disruptions to fluency, speech rate and stress patterns) in connected utterances might explain this. Ertmer (2010) examined this relationship between articulation and intelligibility in a study involving forty-four children (age range 2;10-15;5) who had hearing impairment. The children's percentage scores on the Goldman-Fristoe Test of Articulation-Second Edition were compared with percentage intelligibility scores obtained from imitated or read sentences orthographically transcribed by three listeners. The results indicated that there was a relationship between the intelligibility and word articulation scores which was "significant but not especially strong" (p. 1081). Interestingly, even when scores for single word accuracy were relatively high this did not result in correspondingly high levels of intelligibility in connected speech.

These findings raise questions about what has been found when measuring intelligibility using different types of speech, particularly single words and utterance level data.

2.4.2 Measurement of intelligibility using different sampling methods

There seems, at best, a moderate correlation between segmental accuracy in single words and intelligibility in multi-word utterances. However, this does not immediately indicate whether intelligibility in single words and multi-word speech shows any clinically significant differences. If, for example, intelligibility in single words was very similar to that obtained in multi-word speech, it might only be necessary to sample single words which would have advantages in terms of speed of data collection and subsequent analysis. The studies to date suggest that it is unlikely that this is the case (particularly for every child), but it is, nevertheless, worth exploring.

There are studies that have used both single word and utterance level stimuli to measure intelligibility but the findings have been contradictory. In a study of five children who had PSD, Pascoe, Stackhouse and Wells (2006) found that two of the five children had single word intelligibility scores that were significantly below those of their spontaneous speech but three of the children showed no significant differences. It was not the case that these measures simply related to overall severity since one child who had less intelligible single words, and one whose scores on single words and spontaneous speech were similar, could be both categorised as having very severely impaired speech, as measured by PCC based on a single word naming test. Both the single words and spontaneous speech intelligibility measures were carried out using an open-set task; Vigouroux and Miller (2006) suggested in their study of adults with Parkinson's disease, that this approach may be more sensitive to mild to moderate levels of impairment. Given the emerging picture of variability in findings, it may the case that sensitivity is linked to individual speech patterns in a more fine-grained way than just overall severity.

Faircloth and Faircloth (1970) reported a single case study of an eleven year old child who had severe speech difficulties, comparing production in single words and connected speech, and found a different pattern to that suggested by Pascoe et al. (2006). They reported that the intelligibility of single words was judged to be better than connected speech (although it is unclear how this judgement was made); they suggest this was because the child's realisation of syllable structure was better in single words and that word shape was even more essential in intelligibility than segmental accuracy (a view supported by Klein & Flint, 2006). In a study of intelligibility in two ten-year-old children who had severe speech difficulties including vowel production, Speake et al. found that a group of 19 peer group listeners understood both children's spontaneous speech better than their single words. After a programme targeting vowel production, this situation reversed so that single words were slightly more intelligible than multi-word speech. The authors do not comment directly on this but given that vowel production improved significantly in both children, it seems probable that improved vowel accuracy had a greater effect on the (largely) CVC single words than on the uncontrolled segmental (and lexical and prosodic) components of spontaneous speech.

Chin et al. (2001) carried out a study of twenty children (aged 4;8-7;8) who had cochlear implants. The children were recorded saying single words, which were presented to listeners in a closed-set minimal pair task, and imitated sentences from The Beginner's Intelligibility Test (Osberger et al., 1994), presented in an open-set format. They found that intelligibility in the two types of utterance was significantly correlated (or, put another way, not significantly different as with three of Pascoe et al.'s children, 2006). They also make the point that intelligibility at sentence level is helped by "syntactic, semantic and pragmatic support" (p. 200) which might help to explain why some children's intelligibility at single word level is poorer than at sentence level. Gordon-Brannan and Hodson (2000) also found a high degree of correlation between intelligibility in single words and spontaneous speech (as well as imitated sentences, listener ratings and severity) although the variability in what listeners understood was much greater for children who had severe difficulties than for those at the milder end. Interestingly, there was a mean difference in intelligibility of about 10% between connected speech and single words (favouring connected speech) across all levels of severity, although this was not reported as significant.

These studies suggest that although multi-word speech may often be more intelligible than single words, this is by no means a universal finding. Individual children will present with different profiles of intelligibility across different types of speech samples and this presents a compelling case for assessment of both single words and multi-word speech data for each child. Furthermore, children's profiles may change over time so that measuring intelligibility at different points during intervention may be important for children who have severe and persisting difficulties.

If it is the case that children present with individual profiles of intelligibility, it is also relevant to explore studies to find out what it is that makes speech more or less intelligible.

2.4.3 Factors that make speech more or less intelligible

Intelligibility is not only a linguistic phenomenon; it is affected by factors such as the environment where the speaker and listener are talking (for example, the level of background noise) or by interpersonal factors such as the relationship between the people or level of interest in or attention to the topic. It is also influenced by, for example, whether the listener can see the speaker as well as hear him because visual information has been shown to boost intelligibility (Hunter, Pring, & Martin, 1991). At a linguistic level the intelligibility of a child's speech may be affected by a variety of "pragmatic, contextual and linguistic variables" (Weston & Shriberg, 1992, p. 1316). The variability of these factors is magnified in conversational speech where holding a conversation may be viewed as "a series of events" (Flipsen, 2006, p. 303) with the potential for variation in the speaker's output throughout. This variation may take the form of differences in intensity or rate, the content and complexity of the utterance or in segmental and prosodic patterns. These factors affect all speakers but for children who have speech difficulties understanding the interaction between what happens in typical variation, and what happens as a result of their speech differences is essential in order to explain their "moment to moment unintelligibility" (Weston & Shriberg, 1992 p. 1316).

In adult studies, carried out with people who had dysarthria, articulatory factors seem to be the biggest contributor to poor intelligibility (for example, De Bodt et al., 2002), although prosodic factors also have impact. However, this is perhaps unsurprising given the nature of the acquired speech difficulties associated with neurological conditions (Weston & Shriberg, 1992) and intelligibility in children might be influenced by a wider range of linguistic factors. However, Weston and Shriberg (1992) also make the point that difficulties in speech output must be a major factor because children who have typical speech production are usually intelligible.

Speech output patterns were examined by Hodson and Paden (1981) who considered the phonological processes of sixty children (age range 3;0-8;0) who had unintelligible speech in comparison to sixty typical four year olds. They found that the speech patterns of typical children aged four were characterised by (in order of frequency): devoicing of word-final obstruents; /f/–/θ/, /v/–/ð/ substitutions; liquid gliding; interdental/dental tongue position i.e. lisps; depalatalisation of /ʃ, ʒ, ʧ, ʤ/; assimilations. By contrast, the unintelligible group were characterised by (in order of frequency): cluster reduction; stridency deletion; stopping of fricatives; gliding of liquids; assimilation; velar fronting or omission; backing; final consonant deletion; syllable reduction; prevocalic voicing; glottal stops. The authors also found that the majority of the group had a small number of atypical or idiosyncratic patterns; they also commented on the individual variations within and between the patterns that children had, and that children showed preferences for particular patterns. They concluded that four of the most common processes (cluster reduction; stridency deletion; stopping; assimilation) had a significantly negative impact on intelligibility (gliding of liquids, the only one found in both groups, did not) and also that uncommon processes such as backing were important in the intelligibility of individual children.

The frequency of occurrence of particular speech patterns was explored by Yavas and Lamprecht (1988) in a study examining the speech output and corresponding intelligibility of four Brazilian children aged 7 to 9 years who had speech difficulties. They found that cluster reduction, final liquid deletion (important in Portuguese) and obstruent devoicing were the most common processes. They also found that the number of processes that the children had related to their intelligibility, in that the two most unintelligible children (as judged by twenty listeners in a write-down task) had the greatest number of phonological processes. However, once the four children were divided into the two most and two least intelligible, the correlation with quantification was no longer straightforward. The child judged most intelligible had more phonological processes than the second most intelligible; the two least intelligible had very similar numbers of speech processes but 5 of 20 listeners judged one to be more intelligible than the other. Further analysis explored possible reasons for this. In the two least intelligible children processes affecting structure (syllable and sound deletion) and assimilation had greater impact than substitution processes (see also Barnes et al., 2009), and the least intelligible child showed more variability in realisation of adult targets. In the two most intelligible children variability was again highlighted, with the suggestion that it is more difficult for listeners to establish what patterns a child is using (and thereby understand the speech) when there is low consistency in the speech produced. In a later study, Weston and Shriberg (1992) also reported that cluster reduction affected listeners' understanding of children's speech; in addition they suggested that multisyllabic words presented difficulties (these two factors were also identified by Monsen, 1983) and that nouns were generally more intelligible than verbs, pronouns or modifiers (although Hustad (2006b), in a study with adults who had dysarthria, found that function words were more accurately transcribed than content words). However, Weston and Shriberg (1992) caution that "the data were noisy" (p. 1328) and that the interactions of factors such as utterance fluency and length, and children's syntactic and lexical skills, together with their speech output difficulties may need to be understood to better explain their intelligibility.

In an attempt to isolate the impact of different phonological processes, Klein and Flint (2006) carried out a study where an adult with typical speech read sentences to listeners; the content was manipulated to reproduce three common phonological processes (final consonant deletion (FCD); stopping of fricatives and affricates (SFA); velar fronting (VF). They concluded that in utterances where the frequency of occurrence was like that of typical speech, FCD had the greatest impact on intelligibility followed by SFA and then VF. If the stimuli were artificially manipulated to equalise the numbers of occurrences these differences were no longer apparent suggesting that these processes affect intelligibility incrementally, depending on the frequency of possible occurrences. Of course, a process such as FCD may affect a much wider number of segments and by association, words, than for example, VF and, as the authors suggest, there may a difference in processes that affect manner rather than place of articulation. They also make the point that beyond a certain point of severity, it may not matter, or even be possible to describe, which processes have more impact because the overall output is so degraded; they describe this as "a ceiling effect for unintelligibility" (p. 195). Conversely, it may be that segmental accuracy *per se* is not the issue but that segmental accuracy is an indicator of the child's overall speech production skills (Carney, 1986); it may be, for most children at least, that emergence of segmental proficiency is accompanied by an emergence of suprasegmental and linguistic proficiency and these things together impact positively on intelligibility.

In summary, intelligibility is affected by a variety of factors both non-linguistic and linguistic. In terms of children's speech output, the literature suggests that there is an association between severity as measured through PCC and the occurrence/frequency of simplifying processes, and that patterns affecting word structure (for example, reduction of consonant clusters or final consonant deletion) have a particularly negative effect on intelligibility. It seems to be the case that not all processes are of equal importance and that variability in production impacts on the experience of listeners. (There are also significant variables in listener perception, as yet poorly understood). However, there is also a strong suggestion that although the accuracy of segments in relation to adult targets is an essential element of being understood, this may not adequately explain the intelligibility of individual children. Interactions between segmental patterns and other linguistic elements must be important but, as yet, there is no cohesive framework to explain these either clinically or empirically.

2.5 Research questions

Themes identified through the review of the literature were used to formulate six research questions. These questions were designed to be explored through a study of the speech processing skills, output patterns and intelligibility of four children who had severe and persisting speech difficulties.

1 What will the detailed perceptual phonetic investigation of the speech of children with PSD speech reveal in terms of a traditional phonological process analysis (PPA)? What features are not captured through a traditional PPA?

2 What does comparison of the patterns in the children's speech data reveal across three speech elicitation conditions (1: single word production; 2: connected speech in sentence imitation; 3: connected speech in spontaneous conversation)

3 Does the children's speech output show phonetic variability within individual speech elicitation conditions?

4 Does the psycholinguistic speech processing profile provide explanations of the children's speech output patterns?

5 Does the intelligibility of the children's speech vary across different speech elicitation conditions?

6 Are any changes in the children's speech output evident between two points in time and do any changes impact on the intelligibility of his or her speech?

These research questions were explored in the investigation of four individual case studies described in Chapters Four, Five, Six and Seven. The methods used for these case studies are described in the next chapter, Chapter Three.

Chapter Three

Methods

3.1 Introduction

The purpose of this chapter is to describe the participants in the study, the materials used and procedures for analysis of the children's speech processing skills, speech output and intelligibility.

3.2 Design outline

The study was designed to carry out a detailed analysis of the speech processing skills and speech output of four children who had persisting speech difficulties (PSD) at two points in time, T1 and T2. The analysis included detailed impressionistic transcription and examination of phonetic, phonological and prosodic patterns in single words, imitated sentences and conversational speech. Edited samples of different types of utterances from T1 and T2 were played to groups of adult listeners (66 individuals) who were asked to write down what they thought the children had said. The intelligibility outcomes were examined and compared, and results considered in the context of the speech analysis.

A single case design was selected as there are few detailed descriptions of the characteristics of children with PSD and those that are published reveal that these children are not a homogenous group (see Pascoe, Stackhouse & Wells, 2006, for examples of detailed individual intervention studies of a small number of children with PSD). This homogeneity can be illustrated through an examination of published research studies based on the intelligibility measurement of groups of children with speech difficulties. These reports typically reveal a wide range of outcomes (see, for example, Peng et al, 2004; Gordon-Brannan & Hodson, 2000; Ertmer, 2010) but offer little exploration of this variability. Single case studies were essential in order to carry out the analysis of speech processing and intelligibility in the detail needed to investigate the research questions; "their unique undividual characteristics" (Perkins & Howard, 1995, p. 22). Although it would not be possible to generalise findings from this type of study (Pring, 2004) to the wider population of children with PSD, utilising a single case design "offers the practitioner a detailed and in-depth analysis...at the level of the individual" (Vance & Clegg, 2012).

The resources available (in terms of time available for data collection and analysis) allowed for the inclusion of four children in the study, and for detailed measurements at two points in time. The purpose of having two points of measurement was to allow the investigation of any change in the children's speech, speech processing skills and intelligibility between time one (T1) and time two (T2), allowing for an exploration of the relationships between these factors in each child.

3.3 Participant criteria

There were two sets of participants: four children who had PSD, and 66 adult listeners. The inclusion and exclusion criteria for each group are described in the next 2 sections.

3.3.1 Children with PSD

In order to participate in the study, the children had a diagnosis of persisting speech difficulties. The criteria used for participant inclusion were that their primary difficulty was in speech development; that they were over the age of 5;6 (Bishop & Adams, 1990; Pascoe et al., 2006); they had received speech and language therapy for at least two years, on the basis of this showing that they were slow to respond to intervention (Wood & Scobbie, 2003), and that there were on-going concerns about their intelligibility as evidenced by their referral to the study by their speech and language therapists. The children's receptive language skills should be within the range typical for their age to exclude more wide-ranging linguistic or cognitive concerns. In order to reduce possible sources of prosodic differences the children should be monolingual English speakers and not be diagnosed with hearing impairment or autism spectrum disorder.

All four children met these criteria for the clinical presentation of PSD; they had age-appropriate receptive language skills; their age range at T1 was between 6;5 (Tallulah) and 7;5 (Harry); all had been referred for speech and language therapy between the ages of 2;0 (Tallulah) to 3;1 (Harry and Lily) and had received a variety of intervention since that time. In spite of this intervention they continued to have difficulties with speech sounds and intelligibility, the range and extent of which was confirmed during the assessment at T1.

3.3.2 Adult listeners

The adult listeners were recruited from groups of health professionals who worked in the field of paediatric healthcare. There were no inclusion or exclusion criteria for the adult listeners. There was no requirement to be a monolingual English speaker.

3.4 Research ethics

The study was submitted to the local NHS research committee and approved. It was also approved by the local Primary Care Trust (later the NHS Community Services Trust) Research and Development Committee, in accordance with the Department of Health Research Governance Framework and in compliance with Standards for Better Health (see appendices 3.1; 3.2).

3.5 Informed consent

All participants were recruited following appropriate and approved procedures. Consent included permission for audio and video recording of children. Consent for children to participate was given by parents in all cases. Although information and consent forms had been designed for use with children, none of them were judged to be sufficiently mature at T1 to give informed consent.

All adult participants were given information sheets and consent forms which were completed and signed.

3.6 Confidentiality

All data (including audio and video material) were treated according to appropriate and approved procedures to protect all aspects of confidentiality as agreed through the research ethics process.

3.7 Participant recruitment and information

Participants were recruited though the process identified and agreed through the research ethics process.

3.7.1 Children with PSD

The children who had PSD were recruited through the speech and language therapists who worked for the NHS Community Services Trust. The inclusion criteria for the study were discussed with speech and language therapy team who were given information sheets and consent forms. They were asked to approach families who had children who might be suitable and ask if they would consider participating. Those families who expressed an interest were offered an initial session with their own therapist and the author so that the suitability of children could be assessed. Through a 12-month period nine children were considered and four selected. Children who were not selected were those judged to be progressing well and/or not presenting with major intelligibility problems or, in one case, judged to have specific language impairment which significantly affected receptive language. Information gained at these sessions was discussed with the local therapist and parents, and advice given regarding intervention targets in the format of a standard second opinion visit. The four children who were judged suitable for the study were transferred to the author once the process of informed consent was completed.

The four children who participated were assigned pseudonyms to preserve confidentiality (see table 3.1).

Table 3.1: Participant information, children

Name (pseudonym)	Age at T1 (years; months)	Age at T2 (years; months)	Time between T1 and T2
Hamish	6;7	7;7	12 months
Harry	7;5	8;5	12 months
Lily	7;2	8;11	19 months
Tallulah	6;4	7;3	11 months

3.7.2 Adult listeners

The adult listeners were recruited from health professionals; speech and language therapists, physiotherapists, occupational therapists and community paediatricians who might have contact with children who have speech disorders in the course of their working day. Recruitment was initiated by discussion with local service managers; the process of informed consent was completed as described. Sixty-six adult participants were recruited to the study.

The 66 adult listeners, referred to as L1, L2 (listener 1, listener 2) etc. were made up of health professionals as follows:

- 12 occupational therapists
- 9 physiotherapists and 1 physiotherapy assistant

- 29 speech and language therapists and 7 speech and language therapy assistants
- 8 community paediatricians

3.8. Local accent

The children participating in the study were all born and live in East Anglia where the local accent is a variant of Southern Standard English. However, accents in the area vary between "the broadest local accent up to Near-RP and RP" (Wells, 1986, p. 336) and each child had a slightly different variation. In line with the description by Wells (1986), they all had a long [ɑ] in words like BATH [bɑ θ] and were non-rhotic. Vocalisation of SFWF /l/ to [ʊ] as in BELL [bɛʊ] was typical. Lily's accent was more like a London accent with for example, / θ / realised as [f] and SFWF /ŋ/ as [n] in ING verb endings. Harry might also realise /ŋ/ as [n], reflecting a typical feature of many speakers in his local rural community. Both Tallulah and Hamish were Near-RP but in line with their peer group all the children were liable to realise within-word and SFWF /t/ as glottal stops.

3.9 Materials

Materials are described as used for the speech sampling and psycholinguistic assessment of the children and for the intelligibility task.

3.9.1 Children with PSD

Details of all the assessments used throughout the study are given; the tasks used with individual children varied slightly as did tasks completed at T1 and T2; these variations are described in each case chapter. Materials included both standardised and non-standardised published assessments; data from these assessments were used for speech sampling.

The children's speech processing systems were assessed using activities from the *Compendium of Auditory and Speech Tasks* (Stackhouse et al., 2007). The authors provide mean age scores for children aged 3-7 years across a range of psycholinguistic tasks which can be norm-referenced through calculation of z-scores based on the child's raw score and mean and standard deviation for the relevant age group. Tasks are used to examine speech perception and discrimination skills; indirectly, phonological representations and motor programmes; speech output skills. Details of the individual tasks and stimuli are given in appendices 3.3 to 3.20. The activities were based on the published stimuli in order to examine the children's performance against the norms. However, it is acknowledged that using stimuli based on children's own output patterns might be more sensitive in the investigation of individual psycholinguistic processing strengths and difficulties (see section 8.8 for further discussion).

Phonological awareness skills were assessed using the *Test of Phonological Awareness* Hatcher (1994) which does not provide norms other than an expectation that children will be able to manage the tasks by the age of approximately 7;0 years. This assessment was chosen because it was used by the clinicians in the author's speech and language therapy service; other normed tests were not available. Tasks involve a mix of input and output skills: syllable blending (e.g. "what word am I saying: 'win-dow'?"); phoneme blending (e.g. "what word am I saying: 's-t-e-p'?"; rhyme (e.g. "Which word does not rhyme: bun, hug, mug?"; phoneme segmentation (e.g. "how many sounds in 'pet'?"; phoneme deletion (e.g. "what word do you have if you take 'g' away from 'gone'?"); phoneme transposition (e.g. "what word do you make if you reverse the sounds in 'ten'?".

The children's speech output skills were also assessed using the *Diagnostic Evaluation of Articulation and Phonology* (DEAP) (Dodd, Hua, Crosbie, Holm, & Ozanne, 2002). This test allows for diagnostic testing of output: single words; stimulability at single sound and CV/VC level and oro-motor skills. For this study the diagnostic screen was not used to select which subtest was used because the aim was to collect a large number of single words, and also to allow for repetition of items that occurred in more than one subtest for example, PIG, SNAKE and ZEBRA. The subtests of the DEAP used were The Articulation Assessment, The Phonology Assessment and The Inconsistency Assessment. The Articulation Assessment involves naming 30 pictures, mainly with a consonant-vowel-consonant (CVC) word shape. It targets the majority of English vowels and consonants in onset and coda positions. It also includes a speech sound stimulability task which allows the examiner to probe for segments not realised in the naming task through elicitation in CV and VC syllables, or as single sounds. The Phonology Assessment involves naming 50 pictures targeting all English consonants in onset and coda positions, and the majority of vowels. The task allows opportunities for multiple realisations of word shapes (e.g. word-initial consonant clusters) and segments (e.g. velar plosives and affricates) which might be subject to common error patterns such as cluster reduction, fronting of velar plosives or deaffrication. It is suggested that 5 or more occurrences (or 2 examples of weak syllable deletion) allows for reliable identification of what is termed an error pattern. The Inconsistency Assessment consists of 25 pictures which are named on three separate occasions during the same session. The three realisations of each of the 25 items are compared. If 40% or more of the individual words are produced differently the child may be diagnosed with inconsistent phonological disorder.

Oro-motor skills were assessed using the DEAP tasks but not scored against the norms given because there were concerns about reliability in this study. The test involves isolated movements (tongue protrusion to outside the upper lip, side to side movements, lip pursing and spreading) and sequenced movements (blow and then elevate tongue tip; kiss and then cough; yawn and then lick the side of mouth).

Diadochokinesis was assessed informally through repetition of the sequence /p/, /t/, /k/ up to 10 times. This was not carried out following any published procedure. The original intention was to use the procedure described in the DEAP but this proved too difficult for these children and use of this procedure would result in them being unable to achieve any accurate sequences. Use of a modified procedure allowed more detailed evaluation of the children's skills by noting the number of repetitions of the individual sounds and the sequence that was required for each child to achieve production of the sequence. The children were given a model, first of repeated productions of the single segments e.g. [p], [p], [p] and then in a sequence. They were then given practise trials until at least one approximation was produced (apart from Hamish who was unable to realise the velar plosive; he was encouraged to make an attempt since previous intervention was reported to have elicited the target). There was no request to repeat the sequence rapidly, although the model was of rapid production. Given the repeated modelling and trials, and attempts to facilitate production, scoring of the task against the norms given in the DEAP was considered to be unreliable. The task was audio and video recorded, and administered after the oro-motor activities.

Speech sampling data were taken from three contexts:

1. Single word production from the DEAP Phonology, Articulation and Inconsistency subtests and The Picture Naming Test (Stackhouse et al., 2007): these gave 109 (Lily), 110 (Harry) and 112 (Tallulah and Hamish) single words varying between 1 and 4 syllables in length (see individual case chapters for details);

2. Imitated sentences from the Connected Speech Processes (CSP) Repetition Task (Stackhouse et al., 2007); this gave 42 sentences designed to assess children's word juncture behaviours (see individual case chapters for details);

3. Conversational speech: samples of spontaneous speech in conversation were used for segmental and prosodic analysis (see individual case chapters for details).

3.9.2 Intelligibility task

1. Audio and video recording speech data

Audio data were recorded using an Edirol R-44 digital recorder with an SE Electronics SE2A external microphone. Video data were recorded on a Sony digital video camera, DCR-SR35E. The analysis of the audio data was supported through use of Acoustica 4.1 and PRAAT (Boersma & Weenink, 2013) software.

2. Listener responses

A response sheet for the listeners was designed (see appendix 3.21). It provided a front sheet asking for name, professional group, age band (under 21, 21-30, 31-40, 41-50, 51-60, over 60), experience of working with children who have speech difficulties (the descriptive terms used were "little", "some" and "lots") and first language spoken. The front sheet also provided a place to record the practise items. This was followed by a page for each word list, headed by a list number with 25 spaces for responses on each page.

Randomisation for the presentation of intelligibility data samples was carried out using a website that was signposted by a Google search; www.psychicscience.org

The sound files were played though a standard Dell laptop using an Altec Lansing XT1 two-piece USB powered portable audio system.

3.10 Procedures for data collection and analysis

3.10.1 Speech processing data collection

Children's speech data were collected at T1 and T2 using the assessment materials described.

The data for T1 were collected during the initial assessment sessions. The assessment process took place during 3 sessions of approximately 1 hour each. Sessions took place one to one in a quiet room usually in the child's school; Tallulah and Harry were both seen in the clinic with their mothers for their first appointment, but thereafter at school. Data for T2 were collected at school with the exception of Tallulah who was seen at home.

All the children were familiar with the process of assessment because they had all been tested on previous occasions using a variety of speech, language and literacy tasks.

All the assessment sessions were simultaneously audio and video recorded. The recordings were transferred to a computer for the purposes of analysis.

3.10.2 Speech processing data analysis

Data from the assessments were analysed in the context of the children's input and output speech processing skills and summarised on a Speech Processing Profile and then mapped to the suggested areas of difficulty on the Speech Processing Model (Stackhouse & Wells, 1997). Where age norms were available, the children's performance on both input and output tasks were compared with typical peers and z-scores calculated.

The data from the audio and video files were analysed by orthographic and phonetic transcription of single words, imitated sentences and examples of conversational speech (see individual case chapters for details) using symbols from the IPA (IPA, 1999), extIPA (Duckworth, Allen, Hardcastle, & Ball, 1990) and VoQS (Ball, Esling & Dickson, 1995). Very occasionally data from conversational speech not included in the appendices were used for further illustration; this is indicated in the text in the case study chapters. Approximately 10% of the data were independently transcribed by the author's PhD supervisor, and a final transcription was agreed between the two transcribers, aided by the consensus approach suggested by Shriberg, Kwiatkowski and Hoffman (1984) and by recourse to acoustic analysis using PRAAT (Boersma & Weenink, 2013). Consideration of the methodological and theoretical flaws of reliability measures using point-to-point symbol agreement (Cucchiarini, 1996; Howard & Heselwood, 2011; Heselwood, in press) led to a decision not to use this approach for these complex data. This was felt to be particularly important as some of the detailed transcriptions contained many diacritics and although it is well-known that the more detail in the transcription the less listener agreement there is likely to be (Shriberg et al, 1984), it is also the case that different diacritics and symbols may sometimes imply the same or very similar auditory percept (Cucchiarini, 1996; Howard, 2013). The level of detail in the transcription varied and this was decided by the purpose of each example, and patterns of interest that required further analysis.

Following transcription, further analyses were carried out:

(1) Compilation of a phonetic inventory from the single word (SW) and multi-word speech (MW) samples
(2) A PCC (percentage consonants correct), PVC (percentage vowels correct) and PPC (percentage phonemes correct) analysis of the single words
(3) A phonological process analysis of word production in SW and MWU
(4) An examination of word juncture and connected speech behaviours in the multi-word data

The approach to calculation of PCC was different to that espoused by Shriberg and Kwiatkowski (1982) who worked from conversational data. Pascoe, Stackhouse and Wells (2006) present the view that PCC analysis of MWU samples where intelligibility is compromised "may not be practical [because] target words are not known" (p. 94). This is the rationale followed in the analysis of multi-word utterances in this study.

3.10.3 Intelligibility task data collection

Ten single words, five imitated sentences and five samples of conversational speech from each child were edited for use in the intelligibility task. Each child had their own set of stimulus items; the same set of single words and imitated sentences were used at T1 and T2. Conversational speech samples were obviously different at the two points in time (see individual case chapters for details). The rationale for using both single words and multi-word utterances was that the literature review had indicated that intelligibility of individual children cannot be assumed to be the same in all sample types. The two different types of multi-word samples were used because imitated sentences could provide a direct comparison using the same data between T1 and T2 but conversational speech has been described as having more ecological validity (Kent et al., 1994; Local & Walker, 2005). Each child had a different selection of words to reduce possible effects of learning by the listeners (Pascoe et al., 2006).

The ten single words for each child were selected at random from 56 items in the DEAP assessment (49 from the phonology test plus seven from the articulation test, numbered 1-56); the imitated sentences were from the 42 items in the Connected Speech Processes

(CSP) Repetition Task (Stackhouse et al., 2007). Randomisation was carried out in alphabetical order (i.e. Hamish first and Tallulah last); if an item selected had already been allocated, the next unallocated number was selected.

The conversational speech samples were collected in the same way at T1 and T2. They were taken during the first assessment session for each time point; each session started with informal conversation and the samples were edited from these interactions after approximately five minutes of talking. This time allowed for the children to settle into the situation, particularly where they were less familiar with the author during the sessions at T1; then the next five intelligible utterances were used. In order for listener responses to be scored using the same method as the single words and imitated sentences, the stimuli had to be recognised by the author. Unlike the single words and imitated sentences, where the targets were known, there was therefore an inherent bias in the conversational samples, which had the unavoidable status of being intelligible at least to a listener who was very familiar with the child's speech since these were selected on the basis of a level of intelligibility already being identified. This is a major weakness in the study design (see section 8.7 for discussion about this issue).

The conversational samples were selected on the basis that each was a complete utterance following the guidance of Shriberg and Kwiatkowski (1982) (citing Davis, 1937; Templin, 1957).

> "An utterance is defined as "....the child 'comes' to a complete stop, either by letting the voice fall, giving interrogatory or exclamatory inflection, or indicating clearly that he [does] not intend to complete the sentence" (p. 267)

Samples were judged to be complete utterances which were intelligible to the author, but were not controlled for content or length. Utterance length was between 3 words (Lily: "we maked decorations") and 13 words (Harry: "Well they basically had a spare one that they brought from their boat"). The mean length of utterance across all samples was 6.62 words.

The single word, imitated sentences and conversational speech samples for the intelligibility task consisted of 200 items (the individual stimuli are referenced in each child's case chapter and can be found in appendices 4.10, 5.10, 6.10 and 7.10):

- A set of ten single words for each child T1 and T2 (100 items)

- As set of five imitated sentences for each child T1 and T2 (50 items)
- Five samples of conversational speech from each child T1 and T2 (50 items)
- An additional 40 items were included from a child (Alice) without a speech difficulty to provide listeners with some examples of typical speech. Alice's data for the intelligibility task was collected in the same way as that of the other children. At T1 she was 7;5 (PCC 97.32%) and at T2, 23 months later, she was 9;5 (PCC 99.66%). From a perceptual perspective there were no developmental speech processes identifiable in her speech output.

These 200 items were numbered and then randomly ordered into eight lists of 25 items. In each session the order of play of the eight lists was further randomised by asking one of the listeners to say the numbers 1-8 in random order which then determined the order of play. This was to reduce the impact any fatigue effects which might occur if, for example, list 8 was always the last list to be heard.

The task was introduced with three practise items, one single word, an example of a child rote counting up to 10 and one example of conversational speech. The playback was paused after each item and the listeners given feedback on what had been said. This was to familiarise the listeners with the task.

Each item was introduced by its allocated number and heard twice in close succession. There was a 4 second gap after each single word and a 12 second gap after each multi-word utterance. Item repetition and time between different utterance types was finalised after piloting the intelligibility task with another group of 10 speech and language therapists. In the pilot task items were heard only once and the gaps between single words and multi-word utterances were 3 seconds and 10 seconds respectively. Discussion with this group resulted in changes as described; no other changes were introduced.

The intelligibility task was carried out with groups of listeners in quiet rooms in their workplace, with the permission of their service manager as part of their regular team meetings. There were five groups, one each for occupational therapists (order of play list: 7,3,1,2,8,6,5,4), physiotherapists (order of play list: 2,5,4,3,1,7,8,6) and paediatricians (order of play list: 6,3,8,7,1,2,5,4), and two for speech and language therapists (order of play list: group one 6,5,2,1,8,3,4,7 and group two 8,4,3,5,1,6,2,7).

The task used an open-set method where listeners were required to identify single words or multi-word utterances and record them orthographically (Hodge & Gotzke, 2007; Hustad, 2012; Kent, Miolo, & Bloedel, 1994).

The listeners were given the following instructions:

- You will hear some children talking. Sometimes it's single words and sometimes longer utterances. You will hear each production twice and then have time to write this down with more time after longer utterances than single words.

- I would like you to listen carefully and write down what you think the child said. Write down what you think he or she meant, for example, if you hear 'tat' and think the child meant 'cat' write 'cat'; if you hear 'I payed in the no' and you think the child meant 'I played in the snow', that's what you write.

- Some utterances will be easily understandable but others are really not and sometimes you might not understand what has been said at all. This is not a test of you as an individual and different listeners will hear things slightly differently; this is quite normal. Please write X if you don't know the word, including in a longer utterance where you can write the words you do understand but put an X if you don't. For example, you might write 'the boy is eating X'. Please put a word or an X for everything you hear.

- You might hear some grammatical errors, for example, 'he eated the mouses, please write what you hear. You may also hear some words or utterances more than once; this is the way that the samples are designed.

- Finally please try not to copy other people: you might be correct in your perception or he or she might be, but it's not a competition! You might also find it helpful to treat each item individually and then move on!

The listeners were asked if they had any questions and then the task was carried out. All groups were offered the opportunity for a break at mid-point but all chose to continue with the task. There was always a very short break between lists as the next list was opened on the computer. The task took approximately an hour to complete. The longest list was list 8 (8 minutes 3 seconds) and the shortest were list 1 and list 5 (each 6 minutes 3 seconds), mean time taken 6 minutes 8 seconds.

3.10.4 Intelligibility task analysis

The listener responses for the different types of speech samples were scored as follows:

- Single words: 1 for each whole word correctly recorded plus 1 for each plural morpheme (for example, for Harry LEG would score 1 point but the target LEGS would score 2).
- Imitated sentences: 1 for each whole word correctly recorded plus 1 for each plural or tense morpheme (for example, for Lily, JOHN COLLECT STAMP would score 3 but the target JOHN COLLECTS STAMPS would score 5). Determiners A and THE were excluded from scoring because it was too difficult to reliably judge the intended target.
- Conversational speech: scored in the same way as imitated sentences.

The approach to scoring verb tenses and plurals is a variation on one taken in other studies. For example, Khwaileh and Flipsen (2010), in a study examining single word and sentence intelligibility in 17 children who had cochlear implants, give the example of scoring the target sentence SHE IS COOKING DINNER. The sentence orthographically transcribed an exact match would score 4 but if the listener wrote "she is cook dinner" it would score only 3. The rationale in the current study is that as the verb or, in the case of plurals the noun, was essential in understanding the whole utterance; this should be credited even if the response was not exact. Hustad (2006a) suggests that it may not matter what paradigm is used as long as examiners are consistent in how samples are scored; consistency is particularly important in test-retest studies to ensure that changes in intelligibility outcomes are not the result of changes to scoring methods.

Following the scoring of responses all items were entered on a spreadsheet and the data analysed as follows:

- Single words, number and percentage correct T1 and T2
- Imitated sentences, number and percentage of words in each utterance correct as per scoring criteria T1 and T2
- Conversational speech, percentage of words in each utterance correct as per scoring criteria T1 and T2 (percentage only scores were used because T1 and T2

utterances were different so that number correct did not provided a direct comparison between the 2 points in time)

T1 and T2 results were analysed using the nonparametric Wilcoxon matched-pairs signed-ranks test.

The methods were used to investigate the research questions and the next four chapters describe the exploration and findings of the individual case studies. The case studies are presented in order of highest to lowest Percentage Consonants Correct (PCC) for each child at T1. The first case study in Chapter Four is Tallulah who was 6;5 at the time of the first assessment.

Chapter Four

Case Study: Tallulah

4.1 Background

At the beginning of the study Tallulah was 6;5; she was referred for speech and language therapy assessment when she was 2;0 because although she understood simple instructions she used fewer than 50 words. She was reported by her mother to "babble in her own language". Tallulah was the youngest of 3 children (a fourth child was subsequently born) and her older brother had difficulties with speech, language and literacy. She was late to walk (22 months) because, by parental report, she had "low muscle tone"; otherwise her developmental history was unremarkable. At the initial speech and language therapy assessment (2;2) she was reported to have age appropriate attention, play and interaction skills and was attempting 2 word combinations. Her speech was difficult to understand and a note in her file records there was "evidence of a lot of nasality". After a period of advice and review appointments, she started regular intervention at 3;5, which continued until the start of this study. There were no concerns about her hearing; subsequent assessment showed all scores in both receptive and expressive language to be within the average range (see appendix 4.1). It is also relevant to note that Tallulah was seen by the lead for the regional cleft team in her local area in the year before the study to investigate her perceptually intrusive nasality; there was no evidence of velopharyngeal dysfunction.

4.2 Initial observations T1 (CA 6;5)

The initial impression of Tallulah was that she was loquacious and keen to engage socially. The most striking feature of her speech was the nasal turbulence that accompanied her realisation of fricative targets, particularly /s/ and /z/, although it also became obvious that her realisation of other consonants sounded immature. She had noticeable difficulties in the production of multisyllable words with a reduction in the accurate production of adult targets which was even more evident than in single syllable words. The intelligibility of her speech was variable. Although there were long stretches of conversation that were intelligible, in spite of atypical segmental realisations, there were instances of utterances, usually a few words or short phrases that were not understandable. Tallulah had recently lost both upper and lower central incisors, and her secondary teeth were at various stages of eruption; this occasionally resulted in interdental articulation of apical segments. She often had noticeable tension in her lips and jaw posture, giving a perceptual impression that her vowels also had a tense quality.

4.3 Initial assessment T1

Tallulah's input processing skills and speech output skills in single words and multi-word utterances were assessed following the approach described in Chapter Three, Methods (see appendix 4.2 for her speech processing profile and 4.3 for the mapping of this profile to the speech processing model).

4.4 Input processing skills T1

The investigation of Tallulah's input processing skills included assessment tasks from Stackhouse, Vance, Pascoe and Wells (2007) and other non-standardised activities.

- Discrimination between same/different SFWF single features and s-cluster sequences, in real words and non-words, for example, lot/loss; vot/vos; lots/lost; vots/vost, (Stackhouse et al., 2007). Tallulah's overall number of responses correct was 33/36 which was equal to the mean score for a child of her age.

- Discrimination of segmental differences between pairs of complex non-words, for example, /spəʊb/ vs. /spəʊd/; /ʧʌsp/ vs. /ʧʌps/, (Stackhouse et al., 2007). Tallulah's performance when judging whether 2 non-words were the same was typical for her age, 100%, (14/14) z=0.73, (mean 93.22%, S.D. 9.26%); her performance when judging difference was 65% (17/26) z=-0.38, (mean 72.28%, S.D. 18.83%), again within the range expected for her age. Four errors were in pairs of non-words where the place of articulation was different (/ˈbɑgli/ vs. /ˈbɑdli/; /sti/ vs. /ski/; /ˈtrɪʒɑ/ vs. /ˈtrɪðɑ/; /ˈkɪrɪvɪn/ vs. /ˈkɪrɪvɪm/), two in voicing (/peɪt/ vs. /beɪt/; /ˈbæskɔɪts/ vs. /ˈpæskɔɪts/) and one each for metathesis (/ˈræliskəʊts/ vs. /ˈlæriskəʊts/), cluster sequence (/ʧʌsp/ vs. /ʧʌps/) and manner of articulation (/ˈkʌsl̩/ vs. /ˈkʌsn̩/).

- Auditory lexical discrimination (ALD) without pictures (Stackhouse et al., 2007). Tallulah was asked to judge whether the multisyllabic items that she heard were real words or non-words, for example, "caterpillar", and /ˈhɒstɪpl̩/. She scored

100% (10/10), z=0.95, for real word judgement, (mean 95%, S.D. 5.22%); 90% (9/10), z=-0.2, (mean 91.67%, S.D. 8.35%) for type A non-words (perseveration effects); 90% (9/10), z=-0.25, (92.5%, S.D. 9.65%) for type B non-words (metathesis effects); all scores were as expected for her age.

Tallulah's phonological awareness skills were assessed using the assessment from the Sound Linkage Training Programme (Hatcher, 1994). Her overall score was 24/36; the test does not give details of norms but is presented as suitable for children at the early stages of literacy development. The activities all require verbal responses. Tallulah was able to listen to words segmented into syllables, for example win-dow, and say the word (6/6). She could also listen to segmented phonemes (for example, r-ai-n) and blend them into words (5/6). Her scores on these tasks indicated that phonological representations for these tested words were accurate. When given a choice of three words Tallulah could identify which two rhymed from auditory presentation alone (6/6), although she remarked "I'm not good at rhymes". She was able to segment words into separate phonemes at CVC level but not when words contained consonant clusters (3/6). She was not able to complete a phoneme deletion task, (for example "take 's' away from 'stop'") (2/6) or carry out a phoneme transposition task ("net" is reversed to become "ten") (2/6) with any reliability. Subsequent comparison of the Hatcher tasks with the phonological ages and stages used in the Sutherland Phonological Awareness Test-Revised (Neilson, 2003) suggested that Tallulah's phonological awareness skills were at an appropriate level for her age.

A number of other informal phonological awareness activities were completed. Tallulah was able to silently sort pictures of CVC words by onset and coda. This suggested that she had some awareness of the internal structure of phonological representations and that these were accurate enough to allow for speech sound identification and segmentation without hearing an adult model.

Tallulah's performance on these assessments indicated that her input processing skills (speech discrimination and ALD) were appropriate for her age; this would suggest that the source of her speech output difficulties was not a difficulty in establishing or storing phonological representations. However, taking a developmental perspective (Stackhouse & Wells, 1997), it is possible that she had such difficulties at an earlier stage and that her speech processing profile at T1 reflected that these difficulties had resolved.

4.5 Speech output skills T1

Tallulah's speech output skills were assessed using a range of single word tests; the Picture Naming Task (Stackhouse et al., 2007), the Non-Word Repetition Task (Stackhouse et al., 2007) and subtests of the DEAP (Dodd et al., 2002). The single word (SW) analysis was based on 112 items collected during these tasks (appendix 4.4). The multi-word data are from the analysis of T1 conversational speech (CS) samples 1-7 (appendices 4.5 to 4.10) and selected imitated sentences from the Connected Speech Processes (CSP) Repetition Task (Stackhouse et al., 2007) (appendix 4.11); there are occasional examples from other conversational speech, which are indicated in the text.

The Picture Naming Task (Stackhouse et al., 2007) allowed comparison of Tallulah's whole word production with the expected score for a child of her age (see table 4.1); scoring is based on the number of whole words that match the adult target. Her overall score across all word lengths was 28/60 (46.66%), z=-5.53, compared with the mean score for a six-year-old of 51.35/60 (85.58%), indicating a severe level of difficulty in comparison with a typically developing peer group. Her scores for 1 syllable (9/20, z=-7.14), 2 syllable (8/20, z=-5.80) and 3/4 syllable words (11/32, z=-3.29) showed difficulties across all word lengths. Although z-scores suggest some differences in the production of words of different lengths in terms of severity in comparison with the typical group, exploration of the errors does not indicate any obvious reason for this; it rather appears to be a chance effect of the lexical items used in the test. It does however indicate the need for further assessment and for word length to be considered as part of the analysis, particularly because initial observations had suggested that Tallulah had difficulties in the production of multisyllabic words.

Table 4.1 Tallulah: Scores for Picture Naming Task & Non-Word Repetition Task T1

	Picture Naming Task (real words)		Non-word Repetition Task	
Word structure	**Norms age 6 years (mean, S.D.)**	**Tallulah's score (z-score)**	**Norms age 6 years (S.D.)**	**Tallulah's score (z-score)**
1 syllable (N=20)	18.35 (1.31)	9 (-7.13)	16.7 (1.22)	17 (0.24)
2 syllable (N=20)	17.50 (1.50)	8 (-6.33)	16.05 (1.23)	12 (-3.29)
3 & 4 syllable (N=20)	15.50 (3.07)	11 (-1.46)	15.00 (2.7)	16 (0.37)
Total (N=60)	51.35 (4.22)	28 (-5.53)	47.75 (4.22)	45 (-0.65)

The Non-Word Repetition Task (Stackhouse et al., 2007) was also completed two months later when Tallulah was 6;7; (see table 4.1). Analysis of these results shows that Tallulah's overall number correct was in the range expected for her age, z=-0.65, as were her scores for one syllable (z=0.24) and multisyllable non-words (z=0.37). However, the number of words correct for two syllable words (z=-3.29) indicated a significant level of difficulty. Unlike real word naming it was possible to relate this difficulty to a particular factor which was the frequency of /s/ cluster targets in the two syllable non-words (in real words segmental difficulties were more diffuse). This accounted for 5 errors in the sample; had those not occurred her scores would have been in the normal range.

Comparison of Tallulah's scores showed that her whole word production was significantly better in non-word repetition than in single word naming. Stackhouse and Wells, (1997) suggest that this profile occurs when children fail to update stored motor programmes as their articulatory proficiency develops over time. They give the example of a child learning the word CAR at a point in time when the velar plosive is fronted, [tɑ]. The child subsequently learns to say [k] and later learned words are produced accurately but CAR continues to be realised in its originally stored form. Tallulah's imitation of non-words which are, in effect, like novel lexical items, indicated that she did have the necessary output skills to produce adult targets more accurately but that she had not yet employed these skills in updating existing motor programmes. In this respect she is like the child DF described Bryan and Howard (1992), although it was not at all certain that the description of "frozen" as applied to DF's speech patterns was appropriate for Tallulah, because unlike DF, she was variable in the accuracy of her output. However, as non-word repetition is less accurate than naming in the normative sample, Tallulah's processing of non-words may not be psycholinguistically stronger than her processing of real words; it may be that her non-word skills are more in line with those of typically developing children and her real word processing skills more different than those of typically developing children.

Non-standardised output-based phonological awareness tasks (Hatcher, 1994) showed that Tallulah could accurately segment words into syllables by tapping or clapping, generate rhymes based on common CVC words and segment CVC words into phonemes, indicating that she was able to manipulate segments and simple words without adult help. She was able to blend C-V-C elements to produce whole CVC words, and if the consonants within the word were typically realised in her own speech, she produced these words accurately (otherwise they matched those predicted from her segmental patterns).

4.6 Oro-motor assessment and diadochokinesis (DDK) T1

Tallulah's oro-motor skills were assessed using items from the DEAP (Dodd et al., 2002).

Tallulah's non-speech movements in isolation (for example, tongue elevation) and in sequences (for example, tongue elevation then blowing) were accurate and performed at an appropriate rate according to the description in the test manual. There was no evidence of oro-motor difficulties.

Tallulah's DDK skills were assessed for rate and accuracy in a non-standardised way through repetition of single segments [p], [t], [k]. She was asked to do this 10 times after being given an adult model and three practise attempts (see Methods, Chapter Three).

Tallulah was able to produce the sequence of [p], [t], [k] maintaining articulatory accuracy for 3 trials but not for more repeats. Beyond 3 trials her productions became more hesitant, she had frequent pauses and made errors in the order of sounds produced; her attempts at repair were often unsuccessful. Tallulah's inaccurate and inconsistent performance was suggestive of difficulties with motor planning (Stackhouse et al., 2007) since she was able to produce the sequence but not maintain accurate output for repeated and rapid attempts.

4.7 Phonetic inventory T1

Tallulah's phonetic inventory, based on single word and utterance level analysis, is listed in table 4 2.

Tallulah's vowel inventory included all vowels expected for her accent of English (see Chapter Three, Methods). In this analysis the realisation of /t/ as a glottal stop in SFWW and SFWF positions and the vocalisation of SFWF /l/ to [ʊ] (Grunwell, 1987) are judged as typical for Tallulah's accent of English.

Table 4.2 Tallulah: Phonetic inventory (consonants) in SW and MWU T1

*	Bi-labial	Labio-dental	Dental	Alveolar	Post-alveolar	Palatal	Velar	Velo-pharyngeal	Glottal
P	p b			t d			k g		ʔ
E				t'			k'		
N	m ṃ͌	f͋ f͌	θ͋ θ͌ ð͌	n ṇ͌ n͋ s͋ z͋ s͌ t͌			ŋ		
F	ɸ	f v	θ ð	s z	ʃ ʒ	ç	x	ʩ	h
Af					ʧ ʤ				
Ap	w	ʋ		l ɹ		j			

*P = plosive; E = ejective; N = nasal; F = fricative; Af = affricate; Ap =- approximant

4.8 Stimulability T1

Stimulability was assessed using the DEAP items (Dodd et al., 2002). Tallulah's phonetic inventory included all English consonants and vowels. When asked to copy speech sounds in isolation and in CV syllables (part of the DEAP (Dodd et al., 2002) articulation assessment) she had difficulty in imitating the voiceless dental fricative / θ / in a CV syllable.

4.9 PCC T1

Tallulah's PCC was 70.82% and her PVC was 95.41% giving a PPC of 83.11%. Scores were derived from 112 single words. This PCC score puts her speech into the Shriberg and Kwiatkowski (1982) category of mild to moderate difficulties for consonant production (65-89%).

4.10 Phonological process analysis T1

A phonological process analysis was completed using data primarily from single words and conversational speech, supplemented by data from imitated sentences. There was evidence of both structural and systemic phonological processes in all contexts, as well as word level assimilatory errors (see table 4.3).

Table 4.3 Tallulah: Phonological processes (consonants) T1

	Target (SW)	Tallulah's realisation	Target (conversational speech, CS)	Tallulah's realisation
Structural processes				
Cluster reduction or simplification	SPIDER	[ˈp̚ aɪdə]	I'M SCARED OF (CS 3)	[{pp m̥ ˈkʰ ɛ̰əd ə̰v̥ː pp}]
Weak syllable deletion	COMPUTER	[ˈpjut̚ə]	UM-AMAZE WITH DINOSAURS-HE KNOWS EVERY SINGLE DINOSAUR (CS 6)	[ə̃m̰ əˈmḛɪz̥ wɪv ˈdaɪ̃nːd̥ɒ̰̃n̥ (.) ˈhi ˈnəʊz̥ ɛvi ˈs̃ɪŋgʊ ˈdaɪ̃nə̆də̃]
Initial consonant deletion (in weak syllables)	PYJAMAS	[əˈʤɑ̃məz̥]	OH SO-IS IT RECORDING MY VOICE? (CS 4)	[əʊ̰ ˈθ̃əʊ (.) ʔɪz ɪʔ əˈkʰ ɔdɪ̃ŋ maɪ ˈvɔ̰ɪs̃]
Systemic processes				
Final obstruent devoicing	BIRD	[bɜːd̥]	I DON'T KNOW WHICH ONES THAT'S CALLED (CS 6)	[aɪ ˈdəʊ̃nʔ nəʊ ˈwʌʧ̃ wʌ̃nz̥ ˈdæʔs̃ ˈk̚ ɔt']
Stopping	N/A	N/A	1. DINOSAUR (CS 6) 2. SO-SO (CS 4)	{V̤ ˈdaɪ̃n̥t̚ʰ ɔV̤} [d̪əʊ̰ (.) ˈs̃əʊ̰]
Velar fronting	SCOOTER	[ˈfŋ dutə̃]	I LIKE BRATZ (CS 4)	[ˈa̰ɪ ˈla̰ɪt ˈbwæʔfŋ]
Gliding	RABBIT	[ˈwæbɪt']	I WANT TO BE IN RECEPTION AGAIN (CS 2)	[aɪ ˈwɒ̃nə ˈbiʲ ɪ̃n wəˈfŋ ˈs̃ɛpfŋ t̚ ə̃m̰ əˈgɛ̰̃n̥]
Word level errors				
Consonant harmony	SAUSAGE	[ˈʃɒʃɪʤ̃]	THEY HAD A NICE APARTMENT (CS 4)	[ˈdeɪ hæ̰̃n̥ ə ˈnaɪs̃ iˈpʰ ɑ̰ʔnə̰̃nʔ]

Structural processes impacted on the realisation of consonant clusters and weak syllables. Systemic processes included occasional examples of stopping and velar fronting, and complete devoicing of word-final voiced obstruents was frequent as was gliding of /r/. /θ/ was realised as [f] and [ð] as [v], not predicted by her family's accent but common in her peer group. Although Tallulah's speech sound inventory included all English phones, the presence of atypical nasal realisation patterns was pervasive; this is examined in section 4.11.1.

4.10.1 Structural processes T1

There was evidence of structural processes in Tallulah's speech both in SW and multi-word utterances, these processes showed considerable variability between accurate realisation of adult targets and her immature or atypical forms. This could be regarded as a positive indicator for change (Tyler & Lewis, 2005).

4.10.1.1 SIWI and SIWW clusters in single words

There were 31 SIWI and SIWW consonant clusters in the SW sample and 25.8% (8/31) matched the adult target. Fourteen of the clusters were /r/ clusters, 1 was a /w/ cluster, 5 were /l/ clusters, and 11 /s/ clusters (/sw/ and /sl/ were included in this group).

- /r/ and /w/ clusters: the single plosive plus /w/ cluster in Q̲U̲EEN was accurately realised. Of the 14 /r/ clusters 28.57% (4/14) matched the adult target and 42.85% (6/14) were realised as [w] which Grunwell (1987) regards as typical until the age of 4;0-5;0 "and even later in some immature speakers" (p. 225). There was one example, P̲R̲AM realised as [p͡ɸwæ˜n] where the realisation might be described as an affricate followed by [w]. McLeod and Arciuli (2009) report that in typical development /r/ clusters are between 70% (/θɹ/) and 100% (/tɹ/) correct by age 5-6 years. Variability in Tallulah's realisation can be illustrated, for example, by the cluster /bɹ/. This was produced accurately in 50% (3/6) of occurrences (B̲R̲IDGE [bɹɪʧ̥]; UMB̲R̲ELLA [ʌ˜mˈbɹɛlɑ]) but with a glide 50% (3/6) of the time (B̲R̲EAD [bwɛd̥]).

- The remaining 21.42% (3/14) of these approximant clusters showed a pattern of labial harmony; these were:

  1) T̲R̲ACTOR realised as [ˈp͡ɸwæʔt˺ ə];

  2) C̲R̲OCODILE realised as [ˈɸwɒkxəgaɪʊ̈];

  3) HAIRD̲R̲ESSER realised as [ˈˈhɛəbɹɛ˜n̥.ə̃].

- /l/ clusters: 60% (3/5) realisations matched the adult target; P̲L̲ATE [pleɪt']; BUTTERF̲L̲Y [ˈbʌ̤tʰ əflaɪ]; FLOWER [ˈflaʊwə]. The cluster in G̲L̲OVE was realised with epenthesis [gəˈlʌv̥] and /kl/ in VACUUM CLEANER was realised as a voiceless velar fricative [ˈvæʔkjũm xĩnə].

- None of the /s/ clusters were realised in the same way as adult targets and Tallulah's production was variable. McLeod and Arciuli (2009) report that in typically developing children two-element /s/ clusters are between 95% (/sk/; /sl/) and 100% (/st/, /sm/, /sw/) correct by age 5-6 years. Three-element /s/ clusters are between 85% (/spɹ/) and 92% (/skɹ/) correct. There was no predictable pattern in Tallulah's realisations but they could be loosely grouped:

1) Cluster realised with 2 segments with nasalisation of /s/ plus the appropriate second element, 18.18% (2/11); SCHOOL [s̃ kuʊ]; SPONGE [m̥bʌ̃ndʒ:];

2) Cluster realised with 1 segment, 18.18% (2/11); SNAKE [n̥eɪk]; SPIDER [ˈp aɪdə];

3) Cluster realised with 2 segments affected by other phonological processes; velopharyngeal fricative plus velar fronting 27.27% (3/11) as in SCOOTER [ˈʩ dutə˜]; coalescence plus turbulence as in SWING [f̃wɪ˜ŋ]; interdental realisation of /s/ as in SLIPPERS [ˈθlɪpə˜(C̲˜)];

4) Three-element /s/ clusters realised with 2 or 3 segments, plus or minus velopharyngeal fricative and labial harmony, 27.27% (3/11); SPLASH [blæʔʧ]; STRAWBERRY [ˈʩ vwɔvwi]; SQUARE [p˜fwɛə];

5) A cluster in multisyllabic word affected by ICD on the weak syllable, 9.09% (1/11); SPAGHETTI realised as [ɪ˜ʩ ˈgɛti]. The realisation possibly retains some features of the omitted alveolar fricative target through the presence of the nasopharyngeal fricative.

4.10.1.2 SIWI and SIWW clusters in multi-word utterances

There were 36 occurrences of SIWI and SIWW clusters in the conversational speech samples of which 16.66% (6/36) matched the adult model, for example, /pl/ in the utterance IT WAS A PLAY-IS-JULIET AND ROMEO (CS 1) [ˈɪʔ wə˜ʩ ə ˈpleɪ ɪ˜ʩ (.) ˈʤulij:ɛʔ əm ˈwəʊ:m:iəʊ]; /kl/ in the utterance THERE'S A BOY IN MY CLASS (CS 6)

[ˈðɛ˜z̰̊. ə ˈbɔ̰˜ɪ ɪ˜n maɪ ˈk̚ la̰s̰̊]. Production of other clusters followed the same patterns as those seen in single words (see table 4.4.

Comparison between atypical realisations of consonant clusters and their target forms in SW and MWU showed that qualitatively they were the same in that the patterns identified occurred across all contexts. There were no apparent influences of word shapes or segmental contexts on cluster realisations. However, quantitatively clusters appeared to be more likely to be accurate in SW (25.8%) than in conversational speech (16.55 %) with those in sentence imitation more like those in SW with 30% (6/20) accuracy (four /l/ and two /ɹ/clusters). The error types in the imitated sentences were qualitatively similar to those in SW, for example, THE TOY ELEPHANT WAS BROKEN realised as [ðə ˈtʰ ɔɪ ˈɛləfə˜nʔ wə˜z̰̊ ˈbwəʊkə˜n] with /r/ realised as [w]. Targets with SIWI /s/ clusters were realised with velopharyngeal fricatives or alveolar fricatives accompanied by nasal turbulence. There was also evidence of variability, for example, /kl/ was realised in 3 different ways: CLEAN [xlĩn] and [ɟĩn]; CLAIRE [klɛə] and [xlɛə].

Table 4.4 Tallulah: SIWI & SIWW cluster realisation in conversational speech T1

Target cluster type (% sample)	Matches to adult target	Examples of typical production	Error types	Examples of atypical/immature production
/r/ (41.66%, 15/36)	13.33% (2/15)	WORK FOR THE TRIPLETS (CS 4) [ˈwɜ̰ʔ fɔ də ˈtɹɪ̰blə˜̰ʔʧ]	Gliding (46.66%, 7/15)	AND THE BRATZ WHO ARE REALLY KIND (CS 4) [æ˜nd̚ ðə ˈbwætʧ huʷ ɑ ˈwili ˈkʰ ɑɪ˜̰nd̥]
			Labial harmony/assimilation (26.66%, 4/15)	IN MY DRAMA (CS 1) [ˈɪ˜m̂ maɪ̆ ˈbwɑ˜̰mæ̰]
			Reduction to single segment (13.33%, 2/15)	PRETENDING (CS 1) [ˈbɛ˜nt̰ɛ̈˜nɪ˜ŋ]
/w/ (2.77%, 1/36)	100% (1/1)	ONE OF THE BRATZ QUITS (CS 4) [ˈwʌ˜n əv də ˈbwætʧ ˈkwɪːʔts]	N/A	N/A
/l/ (8.33%, 3/36)	100% (3/3)	AND CLAWS AND THAT (CS 6) [æ˜n ˈklɔ˜z̰̊. ə˜n ˈðæʔ]	N/A	N/A
/s/	0%	N/A	Nasal realisation of 1st	THAT'S WHY I'M SCARED

(47.22%, 17/36)	(0/17)		segment followed by target 2nd segment (70.58%, 12/17)	(CS 3) [ˈðæʔç˜ aɪ˜m ˈfŋ kɛəd̥]
			Reduction to single segment (23.52%, 4/17)	I'M SCARED OF THEM-UM SPIDERS (CS 3) [ə˜˘m̩ ˈɟgɛ˘əd̥ ə ˈdʌ˜m ə˜m ˈbaɪdəfŋ]
			Target realised with cluster reduction and velar harmony (5.88%, 1/17)	STEGOSAURUS [ˈkʰ ɛçkɔɟ]

The labial harmony and/or coalescence of /r/ clusters evident in the SW sample also occurred in MWU. Although it was not a high frequency pattern during this current assessment, Tallulah's previous records suggest that in the year before the study it had been a common occurrence. Examples from conversational speech at T1 include; DRAWING A PICTURE (CS 1) [ˈbɔwɪ˜n ə ˈpʰ ɪʔʧə]; TYRANNOSAURUS REX (CS 6) [ˈpʰ aɪ˜nˈfŋ ɔɹəs̆: ˈwɛks̆]. In these CS examples the cluster is reduced to a single bilabial plosive whereas in single words the onsets comprise two segments, which may also be atypically realised as in CROCODILE realised as [ˈɸwɒkxəgaɪʊ̆]. This again may be indicative of the impact of more complex phonetic environment of multi-word utterances compared with single words.

4.10.1.3 SFWW and SFWF consonant clusters in SW and MWU

The most frequently occurring SFWW and SFWF consonant clusters were /nd/ in AND, /nt/ in DON'T and /ts/ as a part of a verb form (THAT'S; QUITS) or plural (TRIPLETS). These final clusters were variable in realisation but the range of variability was dependent on the elements of the target cluster. Plosive clusters had fewer variations and those that occurred appeared to be within a range acceptable in typical speech. For example, /nt/ was realised as [nʔ] and occasionally [n]; /nd/, most usually in the word AND, was realised variously as [n], [nd̥], [nd] and rarely [nt']. Clusters with fricative elements were subject to far greater variation which was related to the realisation of the alveolar fricatives /s/ and /z/. For example, /ts/ in THAT'S IT [ðæʔfŋ ˈɪʔ]; ONE OF THE BRATZ QUITS [ˈwʌ˜n əv də ˈbwætfŋ ˈkwɪːʔts]; THAT'S WHY I'M SCARED [ˈðæʔç˜ aɪ˜m ˈfŋ kɛəd̥]. However, this variability was not different to that seen in singleton fricative segments and unlike other clusters did not appear linked to the more complex demands of producing consonant sequences.

4.10.1.4 Weak syllable deletion (WSD) and initial consonant deletion (ICD) in weak syllables

Weak syllables were vulnerable to deletion in word onset contexts, as in the SW COMPUTER realised as [ˈpjut̚ə] and within-words as in conversational speech where DINOSAUR was realised as [ˈdaɪ˜nsɔ̃]. In the SW sample only 1 of 7 SIWI weak syllables were completely deleted but a further 3 were subject to initial consonant deletion which did not occur in any other context. Weak syllables within words were not deleted in SW, and there were examples of accurate realisations of weak syllables in the onset position as in TOMATO, [tʰ əˈmatʰəʊ̤].

The WSD process was subject to variability so that DINOSAUR, for example, was realised in MWU both with and without within-word syllable deletion. In SW PYJAMAS was realised with initial consonant deletion [əˈʤa˜məz̥] and on another occasion with complete initial syllable deletion as [ˈʤa˜məz̥]. In conversational speech the SIWI /r/ in RECORDING was deleted, IS IT STILL RECORDING MY VOICE [əʊ̰ ˈθəʊ (.) ʔɪz ɪʔ əˈkʰ ɔdɪ˜ŋ maɪ ˈvɔ̰ɪs̥] whereas in the word RECEPTION in the utterance I WANT TO BE IN RECEPTION AGAIN (a word with the same number of syllables and stress pattern and at a similar position in the utterance) the SIWI /r/ was realised as a glide [aɪ ˈwɒ˜nə ˈbiʲ ɪ˜n wəˈɦŋ ˈ sɛpɦŋ t ə˜̰m əˈgɛ˜̰n]. In the imitated sentences there are 6 different multisyllabic words which might be subject to WSD: ELEPHANT (3 occurrences); YESTERDAY (1 occurrence); COMPETITION (1 occurrence); AEROPLANE (1 occurrence); TELEVISION (1 occurrence); BANANA (3 occurrences). Tallulah realised all syllables in the targets on all occasions. There was no evident pattern which predicted whether or not a syllable would be deleted, partially deleted or typically realised in any of the elicitation conditions, although weak syllable deletion within words only occurred in conversational speech suggesting that the phonetic complexity of the environment of multi-word utterances might be a factor in some instances.

4.10.2 Systemic processes T1

Systemic processes affected Tallulah's realisation of particular segments and her phonological contrasts. However, there was a significant degree of variability and comparison with information from her previous records suggested that typical realisations were becoming more frequent. There was evidence of final obstruent devoicing, stopping of fricatives and gliding.

4.10.2.1 Final obstruent devoicing

Complete devoicing of final obstruents might be expected to resolve in typically developing children around the age of 3;0 (Grunwell, 1987), however, this was evident for Tallulah in both SW and MWU. (Partial devoicing ahead of a pause is typical in adult speech). There were 14 instances of this in the SW sample with /d/, /v/, /z/ and /ʤ/ being devoiced, for example, BREA<u>D</u> [bwɛt]; FI<u>V</u>E [fa˷ɪf̚]; PYJAMA<u>S</u> [əˈʤɑ˜məz̥]; BRI<u>DG</u>E [bɹɪʧ̚]. The same segments were devoiced in MWU; these were usually at the end of an utterance as might be predicted by occurrences in typical speech, for example, SFWF /v/ in AND DADDY LONG LEGS I'M SCARED O<u>F</u> realised as [ˈʔæ˜ːnd̥ (.) ˈd̚æd̚i ˈlɒ˜ŋ̊ ˈlɛɡ̊ʧ̊ (.) {pp m̩ ˈkʰ ɛ˷əd ə˷v̥ː pp}]. The exception to this occurring in utterance final position, also seen in this example, was devoicing of SFWF /d/ in AN<u>D</u> which was a habitual production, although this example was also before a pause.

4.10.2.2 Stopping

Stopping of fricatives was relatively infrequent in the data but occasionally Tallulah realised /s/ as [t], as in the SW example DINO<u>S</u>AUR {V̤ ˈdaɪ˜n̪t̚ʰ ɔV̤} and the conversational speech example of <u>S</u>O (.) SO [d̪əʊ˷ (.) ˈs̼əʊ˷]. The DINOSAUR example was very breathy as she spoke in a voice characterising a dinosaur; the <u>S</u>O example was a part of a narrative (CS 4) used for "and the next thing that happened" and she was very focused on her story. Tallulah was a child who particularly enjoyed drama and sometimes, not unreasonably, her attention was more directed towards her interest in being entertaining than towards her speech output patterns. At T1, a point where her speech patterns were changing, these examples of stopping might occur when motor programmes which were established early in her speech development were activated as default patterns. To express this in phonological process terms, suppression of stopping still required some level of attention. In usage-based terms, the activation of more newly established, mature patterns was not yet automatic.

In sentence imitation there were three examples of stopping, so again this represented a low frequency occurrence in the data, two were in SFWF positions and were plural morphemes; the third was SIWI (see table 4.5).

Table 4.5 Tallulah: Examples of stopping from imitated sentences T1

Target (NS 3)	MARY'S SHOE<u>S</u> ARE CLEAN (plural "s")

Tallulah's realisation	[ˈmɛəɹi ( ) ˈʃud ə ˈxlĩn]
Target (NS 26)	SHE PICKED SOME FLOWERS (SIWI)
Tallulah's realisation	[ˈʃ͡ʃi (.) ˈpʰ ɪk' (.) d̚ʌ˜m ˈplæ (.)wəfŋ]
Target (NS 30)	WE FOUND PRESENTS UNDER THE TREE (plural "s")
Tallulah's realisation	[wi ˈfəʊ˜m˺ ˈpwɛ˜(d)ə˜nt ˈʌ˜nd.ə ʤə ˈʧɹi]* *this example is assumed to be stopping rather than cluster reduction because in all other examples of /ts/ Tallulah realised the cluster with two elements, the second one being a fricative

At the age of 5;5 (12 months before T1) it had been noted in Tallulah's record that she frequently stopped fricatives, so it was likely that the stopping encountered in the current data was a residual process. In data recorded in earlier assessments (when Tallulah was 3 to 4 years old) the most usual pattern appeared to be nasal release of all fricatives, although the transcription does not make clear whether these are velopharyngeal fricatives or oral fricatives accompanied by nasal turbulence.

4.10.2.3 Velar fronting

Fronting of velar plosives was another process that occurred infrequently in the sample, although from Tallulah's case notes it appeared to have previously been a major process in her speech; the examples encountered in this study were therefore likely to be residual difficulties. In SW the only example of velar fronting was with the cluster /sk/ SIWI in SCOOTER realised as [ˈfŋ dutə˜]. In MWU it occurred with SFWF /k/ in I LIKE BRATZ realised as [ˈa̰ɪ ˈla̰ɪt ˈbwæʔfŋ]. SFWF velar plosives were vulnerable to variability in production and in SW the realisations included matching the target, for example, SNAKE [n̥eɪk]; glottal stops, SHARK [ʃɑʔ]; frication PIG [pʰ ɪːx], and affrication BOOK [bʊ̰k͡x].

4.10.2.4 Gliding

Tallulah's realisation of the approximant /r/ was also variable, especially in SW. Although gliding was common in SIWI positions, for example, RING [wɪ˜ŋ], ROOF [wuf̚ː], she also used labiodental and post-alveolar variants, as in RAIN [ʋeɪ˜ːn] and ROUNDABOUT [ˈɹəʊ˜ndəbaʊʔ]. This variation mirrors that found in clusters, as previously described in section 4.10.1.1. In MWU she almost always used [w], for example, AND THE BRATZ WHO ARE REALLY KIND [æ˜nd. ðə ˈbwætfŋ huʷ ɑ ˈwili ˈkʰɑɪ˜̰nd̪]. In the imitated sentences she used [ɹ] on several occasions, for example, THE R̲ED CAR WENT AWAY realised as [ðə ˈɹɛg˺ kʰ ɑ ˈwɪ̃nt͡ ə̆ˈweɪː] but it was equally likely to be realised in an immature form.

4.10.3 Word level assimilatory errors

Tallulah's speech showed occasional evidence of consonant harmony both in SW and multi-word utterances. It was not a major feature of her speech patterns but its presence at all was indicative of the persisting nature of her speech difficulties.

4.10.3.1 Consonant harmony

Consonant harmony has been described as a structural process which normally resolves by 3;0 (Ingram, 1979; Grunwell, 1987) but it has also been categorised as assimilation (Grunwell, 1987). It occurs in both typical and atypical speech development and involves two or more segments in a word or across an utterance being realised with the same place of articulation (Dinnsen, Gierut, Morrisette, Green, & Farris-Trimble, 2011). The harmonisation of place is a form of structural simplification and particular places of articulation are more vulnerable to consonant harmony than others, notably alveolar to velar placement (Stoel-Gammon & Dunn, 1985). However, it may therefore be more appropriate to describe such occurrences in terms of word level errors (Bates & Watson, 2012) and this is the approach taken in this thesis (see also section 7.10). For Tallulah in SW the example of SAUSAGE, realised as [ˈʃɒʃɪʤ], was the only clear instance of the process with the SIWI and SIWW target /s/ realised as [ʃ]; this was interesting because it suggested that the anticipation of articulatory gesture and airstream for the SFWF segment /ʤ/ was able to override the nasalisation pattern which might have been predicted for the first two consonants. Another example was the realisation of STRAWBERRY [ˈfŋ vwɔvwi] where the 3-element /s/ cluster began with a velopharyngeal fricative [fŋ] followed by a labial sequence [vw] which was repeated at the start of the second syllable as a realisation of the target cluster /bɹ/.

In MWU there were several instances of anticipatory harmony as in the example given in table 4.3, THEY HAD̲ A N̲ICE APARTM̲EN̲T realised as [ˈdeɪ hæ̰̃ɳ ə ˈnaɪs i ˈpʰ ɑ̰ʔnə̰̃nʔ], where the realisation of the SFWF target /d/ in HAD̲ appears to have been influenced by the SIWI /n/ in N̲ICE. This harmony might also have influenced the production of SIWW target /m/ in APART<u>M</u>ENT, although this might be a second anticipatory gesture for the final nasal cluster. An alternative explanation, rather than taking a sequential approach, would be that long domain nasal harmony influenced production across the whole utterance.

4.10.4 Summary of phonological process analysis

The most frequent and potentially most significant phonological process found in Tallulah's speech across all contexts, and one which might impact on intelligibility, was cluster reduction and simplification (Hodson & Paden, 1981; Weston & Shriberg, 1992; Yavas & Lamprecht, 1988). Other processes occurred less frequently and although there was evidence of variability, the variation was usually between simplifying processes and adult forms. However, this analysis so far has not captured all the data which might be important in providing a full description of Tallulah's speech patterns.

4.11 Features not captured through phonological process analysis T1

The phonological process analysis revealed a wealth of information which contributed to the description and explanation of Tallulah's speech patterns and intelligibility. However, in the course of the assessment it became apparent that there were other features which could not be accounted for through a traditional phonological process analysis. These features were examined through further analysis of Tallulah's speech patterns. This included exploration of her nasal realisations of fricatives and of word juncture behaviours in multi-word utterances. In addition, production of multisyllabic words and variability were considered with a view to understanding factors which might impact on the intelligibility of her speech.

4.11.1 Nasal realisations

Atypical nasal realisations were the most striking perceptual feature of Tallulah's speech; these principally affected production of the alveolar fricatives /s/ and /z/ but occasionally also /f/, /v/, /ʃ/, /θ/, /ð/ and the voiceless affricate /ʧ/ (see table 4.6). The form of nasal release was variable with three different patterns identified. Firstly she used a velopharyngeal fricative [ʩ]; secondly, oral alveolar or dental fricatives accompanied by nasal turbulence, for example, [s͋]; thirdly (but infrequently), alveolar or dental fricatives accompanied by nasal emission, for example, [s͊]. In multi-word utterances there were also occasional examples of long domain hypernasal resonance. These types of nasal realisations are the result of different articulatory gestures which are explored in the discussion (4.26.1.2).

Table 4.6 Tallulah: realisation of fricatives and affricates T1

Target fricative or affricate	Target (SW)	Tallulah's realisation	Target (conversational speech CS)	Tallulah's realisation
Alveolar /s/ & /z/	SEESAW LEGS	[ˈtĩn.ɔ̃˜] [lɛɡ̊ ɧ ː]	A LITTLE BIT 'COS I HAVE IT IN SCHOOL ONCE DADDY LONG LEGS	[ə ˈlɪʔʊ ˈbɪ.ʔ kʰ əs̪aɪ ˈhæv ɪʔ ɪ˜n ˈɧ kuʊ ˈwʌ˜.n θ] [ˈd.æd.i ˈlɒ˜ŋ ˈlɛɡɧ]
Post-alveolar /ʃ/ & /ʒ/	TELEVISION	[tʰ ɛləˈvɪðə˜n]		
Labiodental /f/ & /v/; dental θ / & /ð/	BIRTHDAY	[ˈbʌfdeɪ]		
Affricate /ʧ/ & /ʤ/	WATCH	[wɒ˜ʔɧ]		

Tallulah had had palatal investigations which confirmed that she did not have a cleft palate or velopharyngeal dysfunction. Six months before this study started an assessment had shown that that all of her fricatives and affricates were susceptible to being produced with nasal turbulence (although alveolar and post-alveolar targets were also likely to be realised as stops). By T1 nasal turbulence primarily affected only alveolar fricatives, and stopping had reduced in frequency as discussed in section 4.10.2.2. These changes suggested that her speech patterns were positively changing in that fewer targets were affected by nasal turbulence (or stopping).

There is some weak evidence at T1 that context might have influenced how segments were produced in terms of turbulence. In SFWF positions and sometimes SIWI positions Tallulah used the velopharyngeal fricative [ɧ] as in LIGHTHOUSE realised as [ˈlaɪthaʊ˜ɧ]; SOCK as [ɧɒ˜kʼ]; SCOOTER as [ˈɧ dutə˜]. A more strongly evidenced effect was her production of the voiceless alveolar segment /s/ immediately before a bilabial nasal or plosive where it was realised as a voiceless bilabial nasal with turbulence, for example, SPONGE realised as [m̥.bʌ˜nʤː]; HOSPITAL as [ˈhɒ˜m.b ɪtəʊ]; DUSTBIN as [ˈdʌm.bɪ˜n]. There were similar examples for both of these patterns in multi-word utterances: SHE PICKED

SOME FLOWERS, [ˈʃ̃i (.) ˈpʰ ɪk' (.) d̪ʌ˜m ˈplæ.wəfŋ] (SFWF); I DON'T HAVE SANDWICHES, [ˈʔaɪ jəʊ˜nʔ ˈhæ˜v ˈs̃æmwɪʤə˜fŋ] (SFWF); BECAUSE IT'S NICE AND SPICY, [ə˜m bɪˈkʰ əñ̥. ɪʔs̃ ˜ˈd̪aɪs̃ æ˜m ˈm̥̃.paɪs̃i], (voiceless bilabial nasal with turbulence before the SIWI voiceless bilabial plosive in SPICY).

As already mentioned, variability was frequent even within a single utterance. This is illustrated by the following example, IT'S A TYRANNOSAURUS REX realised as [ɪ˜ʔd̪æ˜(.)ˈpʰ aɪ˜nˈfŋ ɔɹəs̃ː ˈwɛks̃]. The voiceless SFWF target /s/ in IT'S was realised (probably) as a glottal stop plus voiced alveolar plosive [d]; the SIWW /s/ in SAUR /sɔ/as a velopharyngeal fricative; the SFWF coda to RUS as a strongly articulated /s/ with a longer than usual duration; the SFWF /s/ in REX as voiceless alveolar fricative, i.e. successfully matched in terms of place of articulation, voicing and manner of articulation with oral friction created at the alveolar ridge, but that there was (due to lack of appropriate velopharyngeal closure) simultaneous audible escape of air through the nasal cavity.

Although almost all alveolar fricatives were realised as velopharyngeal fricatives or with nasal turbulence, both in SW and multi-word utterances there were examples of accurate oral realisation of the adult targets and these appeared to be the result of the particular phonetic or situational context in which they occurred, although again this was subject to variability.

1) SIWI and SFWF /s/ in the utterance (CS1) I MEAN (.) SIX realised as [ə˜m ə ˈmĩn (.) ˈs̃ɪts̃]; this was said with extra articulatory force and was to correct the previous statement that she made:

   J: were there lots of children there?

   Tallulah: about four

   J: about four?

   Tallulah: Um-I mean (.) <u>six</u>

   The extra articulatory (muscular) force, created the acoustic and auditory impression of emphasis, through an increase in amplitude (possibly aided by the pause creating open juncture before the word); this meant that the targets were realised with an oral airstream and the final /s/ was made with a whistled articulation.

2) Utterance final /s/ was realised with an oral airstream in NS 16 GOOD GIRLS ARE NICE [gʊg˺ ˈgɛʊð̃ ɑ ˈnaɪs] and in NS 23 JOHN PLAYED TENNIS [ˈʒɒ˜n (.) ˈpleɪd (.) tʰ ɛ˜ˈnɪʔːts̈] (in this example Tallulah realised the target SFWF segment as an affricate; these were generally produced with an oral airstream). Other than the utterance final position, there is no immediate explanation for the first example but the second utterance, as with example 1 given above, was produced at a slow rate, with extra articulatory force and with open juncture between word boundaries giving the impression of a deliberate style of delivery. This may have given more planning time for Tallulah to produce the target with an oral airstream and again, the phonetic context results in a SFWF affricate.

3) In CS 4 there was a short section within an utterance where fricatives were realised with an oral airstream:

T	And they actually told (Bodeen) and it <u>was so funny</u> because now they don't work for them (laughing)
	[æ˜n ðeɪ ˈʔæs̃li ˈtəʊd˺ bəˈdĩn æ˜n ˈɪʔ wəz̥ ˈsəʊ ˈfʌ˜ni bəˈkʰ əʔ ˈnɑʊ di ˈdəʊ˜nʔ ˈwɜʔ fɔ də˜m]

This appeared to be influenced by the fact that Tallulah was laughing as she was talking, again affecting airflow. The quality of her voice production was "not departing widely from [her] usual speaking voice quality" (Esling, 2007, p. 19). However, it may be the case that "rapid fluctuations in the control of airflow through the larynx" (*ibid*, p. 15) impacted on the air pressure in her vocal tract making an oral airstream more likely. This may have resulted in a tension between Tallulah's habitually used nasal realisation and her less favoured but more accurate oral production of the fricative segments, resolved in favour of the adult target.

One final point about atypical nasal realisations is that there were occasions where hypernasal resonance affected a whole utterance. For example (CS 2), 'COS YOU HAVE TO WORK realised as [{V˜ ˈkʰ əv ju ˈhæf̃ tʰ u ˈwɜ̰ːk' V˜}]. This did not happen frequently, and her vowel resonance was not typically affected by hypernasality. However, it was interesting in the context of Tallulah's nasal realisations of consonant segments, in that it supported the view that motor planning difficulties impacted on the coordination of velopharyngeal movements.

4.11.2 Multisyllabic words

Initial observations had suggested that Tallulah had some difficulties in the production of multisyllabic words, although her scores on single word naming and non-word repetition tests had not reflected this with z-scores of -1.46 and 0.37 respectively. Throughout the assessment it became evident that she did indeed have difficulty with longer words, occasionally in naming tasks, but more particularly in the context of multi-word speech. Further analysis suggested that this was possibly a reflection of a wider difficulty in managing the production of complex segmental sequences. The evidence for this comes firstly from some examples of multisyllable words in SW and conversational contexts, and then from an example of a breakdown at utterance level.

The first example was in the production of the SW CROCODILE in a naming task; Tallulah said: [ə ˈkwɒtəgaɪ˘ ə ˈpwɒʃ ə ˈɸɒk˙ (breath) ə ˈɸwɒk͡xəgaɪʊñ̺]. The repeated attempts appeared to stem from her trying to repair the velar/alveolar placements of the two SIWW plosives but in the process she "lost" the relatively mature SIWI cluster /kw/ which was then realised with the pattern of labial harmony. Although the SIWW /k/ was retrieved, the second alveolar plosive was not. Unusually, she produced nasal turbulence in the SFWF position in a word that did not have a target fricative, although her missed attempts at production did.

In multi-word speech there were frequent examples of difficulties in the production of multisyllabic words:

1) RECEPTION in I WANT TO BE IN <u>RECEPTION</u> AGAIN (CS 2) realised as [aɪ ˈwɒ˜nə ˈbiʲ ɪ˜n wəˈfŋ ˌs̃ɛpfŋ t̚ ə˜̰m əˈgɛ˜̰n̺]. This example illustrates the cumulative impact of several co-occurring processes: velopharyngeal replacement for SIWW alveolar fricative in the second syllable; velopharyngeal replacement and possibly stopping for SIWW post-alveolar fricative in the third syllable; possibly anticipatory consonant harmony between SFWW bilabial plosive at the end of the third syllable impacting on placement of the SFWF nasal.

2) PRETEND (CS 1) (most probable target) with an attempted repair WE GOT SOME (PRETENDING-PRETEND) CALENDARS REALISED AS [wi ˈgɒʔ t̰ə̃m ˈbɛ̃nt̰ɛ̃nɪ̃ŋ (.) ˈbɛ̃n (.) ˈtʰ ɛ̃n ˈtʰ æləndɜ̃ːɱ]. This example possibly relates to a morphological error where Tallulah used the progressive verb tense ending 'ing', then tried to repair this. The SIWI cluster on the first production was reduced to a single voiced bilabial plosive replacing the target /pɹ/, a pattern which did not occur in the SW data. The same cluster in the second production was realised as a voiced bilabial plosive with nasal turbulence. There was open juncture between the first and second syllables, realised as an audible pause, and then assimilation of place of articulation between the SFWF alveolar nasal in her realisation of PRETEND and SIWI velar plosive target of CALENDARS.

3) ACTUALLY and ACCIDENTALLY (CS 4): from a listener perspective these two words realised in close proximity to each other appeared to lose distinction due to the atypical and insufficiently differentiated production. SHE (?ACTUALLY/ACCIDENTALLY) GONE AND SHE (?ACTUALLY /ACCIDENTLY) (?TOOK) FORGOT HER HIGH HEELED SHOES [ʔæ̃n si ˈæsədl̪i ˈgɒ̃n æ̃n ˈsi ˈæsli (gɛ̃n(n)i) (tʰ ʊʔ) fɔ ˈgɒʔ hɜ ˈhaɪ ˈhiʊd ˈs̰ʉːz̰]. The semantic context suggested that the first token was probably ACTUALLY and the second ACCIDENTALLY. She had used both words with greater clarity and definition earlier in the same conversation: ACTUALLY in AND THEY ACTUALLY WORK FOR A MAGAZINE realised as [ˈæ̃nd deɪ ˈʔæʔçli ˈwɜk fɔ ʔə ˈmægəzɪn] and ACCIDENTALLY in WHO ACCIDENTALLY WORK FOR THE TRIPLETS [hu ˈʔæʔçəd̪ɛ̃n̪ʔli ˈwɜʔ fɔ də ˈtɹɪblə̃ʔɱ]. This would suggest that motor planning difficulties underpinned her less intelligible productions with long domain harmonisation impacting across the utterance.

4) STEGOSAURUS (CS 6) realised as [ˈkʰ ɛçkɔj]; Tallulah had just heard an adult label (*"I think it's called a stegosaurus"*) and then used the word in her reply. In psycholinguistic terms, having heard the word once and assuming that STEGOSAURUS was a word unfamiliar to her, Tallulah was required to extract sufficient information to establish a motor programme and repeat what she had heard. Although her input processing skills were adequate, evidence throughout the assessment suggested that her motor planning skills were not. She produced the

word on an oral airstream but it was reduced from four to two syllables. The SIWI consonant cluster was replaced by a voiceless velar plosive and the presence of palatal fricatives in SFWW and SFWF positions was reflective of alveolar fricatives in the adult target.

Further evidence for the difficulties in these examples being related to phonetic complexity is shown in an example of the breakdown of an utterance that occurred in the sentence imitation task where the target was SOME SMOKE BLEW OUT OF THE CHIMNEY (see table 4.7). This example did not contain multisyllabic words but was nevertheless phonetically complex in terms of the fricative and cluster content.

Tallulah started to repeat the target but quickly asked for repetition after an initial attempt. Her request for repetition was in a form showing hyperelision. Her second attempt showed three productions of SMOKE, the middle one of which sounded perceptually more like SNAKE. She then produced a CV syllable that was interpreted as CAN'T and then a louder, fluent utterance BLOWED OUT OF THE CHIMNEY.

This utterance was phonetically complex in terms of the segmental content and it also had an irregular past tense verb which, as seen by Tallulah's eventual output, she realised as a regular past tense. In this task where repetition did not allow Tallulah to select content on the basis of preferred lexical, grammatical or phonetic patterns, she was forced into attempting an utterance that exposed her linguistic vulnerability.

Table 4.7 Tallulah: Example of break down at utterance level (NS 28) T1

J: target	SOME SMOKE BLEW OUT OF THE CHIMNEY
Tallulah	SOME. (?)SOME
	[ɲʌ˜mʌ̤ n̥͆ (breath) g͌ ʌ̰˜mː]
Tallulah	CAN YOU PLEASE SAY IT AGAIN?
	[xə˜˘n͡pli͡ ˈð͌eɪ ə (ə˘)ˈd̪ɛ˜n]
J: target	SOME SMOKE BLEW OUT OF THE CHIMNEY
Tallulah	SOME SMOKE (?SNAKE)-SMOKE- ?CAN'T BLOWED OUT OF THE CHIMNEY
	[fŋ̊˘dʌ̰˜m ˈm̥͌məʊʔ ˈn̥͌neɪʔːk' ˈn̥͌nəʊk' (.) xɑ˜ (.) ˈbləʊd əʊʔ ə˜n̥͌ də ˈʧɪ˜mni]

This vulnerability was evident in her conversational speech, as seen in the four previous data samples. It appeared that multisyllabic words were liable to present difficulties to

Tallulah because they were segmentally complex, and it was this phonetic complexity rather than the individual words themselves that made them vulnerable to atypical or imprecise production. In spite of her non-word repetition being better than real word imitation it may be that she did have some difficulties with motor programming which interfered with the establishment of new motor programmes.

4.11.3 Variability

Variability has been mentioned as characteristic of Tallulah's speech and examples have been given. Tallulah did not meet criteria for Inconsistent Speech Disorder (Dodd, 1995) on the DEAP assessment (Dodd et al., 2002). Indeed, her naming of those SW items showed little variety in production. Bernhardt and Stemberger (1998) comment that "in times of change...variability can arise" (p. 257); this variability typically results in productions that more closely match adult targets. This could therefore be termed progressive variability. This was often the case for Tallulah and with recent progress reported it appeared that her speech patterns were maturing. However, there were examples of variability that appeared to relate to motor planning difficulties, frequently involving the realisation of multisyllabic words and consonant clusters, i.e. in saying words that had more complex sound sequences. These attempts did not always result in more accurate realisations. It appeared that her variability was both of progressive and non-progressive types and required an analysis of individual instances and contexts to explain the patterns that occurred.

4.12 Speech behaviours in multi-word utterances T1

Tallulah's speech production in multi-word utterances was examined through carrying out an assessment of the characteristics of her speech at word boundaries and how this compared to the multi-word speech of other children of the same age. The purpose of this was to investigate an aspect of speech output not captured through a traditional PPA. Tallulah's use of assimilation, elision and liaison, and close versus open juncture was examined both in sentence repetition and in conversational speech.

4.12.1 Word juncture in sentence imitation T1

The ***Connected Speech Processes (CSP) Repetition task*** (Stackhouse et al., 2007) was completed to examine word juncture behaviours in imitated utterances (see table 4.8).

In the assessment task Tallulah showed emerging assimilation and elision; her utterances containing elision and assimilation sites for /d/ showed greater frequency of use than average for a child of her age. However, she showed very little evidence of any type of liaison across word boundaries, using open juncture in these contexts between vowels, as can be seen in the examples given. The reduced use of liaison in these utterances may be related to Tallulah's speed of utterance in imitation. The perception was that she tended to repeat the sentences quite deliberately with marked use of open juncture although the production rate of individual words did not give the subjective auditory impression of being particularly slower than her conversational speech. This perceptual effect was not measured instrumentally but studies by Walker, Archibald, Cherniak and Fish (1992), and Walker and Archibald (2006) suggest that the speech rate of typical children is slower in imitation tasks than in spontaneous utterances so her output rate may be a reflection what is seen in children without speech difficulties. There was no obvious reason why this had particular impact on liaison rather than assimilation and elision. It could be that she found consonant-to-consonant word boundaries in some way easier to articulate than vowel-to-vowel boundaries.

Table 4.8 Tallulah: Scores on Connected Speech Processes (CSP) Repetition task T1

	Score expected at age 6	**Tallulah 's score**	**Example (both typical CSP and atypical open juncture are illustrated)**
Assimilation			
t#	91.57%	50%, (2/4)	YOU EAT PUDDING WITH A SPOON [jə ˈʔip˺ pʊdɪ˜ɒ wɪv ə ˈm.b̥ũn (.) fŋ (.) fŋ]
n#	77.48%	50% (2/4)	JOHN PLAYED TENNIS [ˈʒɒ˜n (.) ˈpleɪd (.) ˈtʰ ɛ˜nɪʔːts̈]
d#	38.1%	100% (4/4)	GOOD GIRLS ARE NICE [gʊg ˈ˺gɛʊð a ˈnaɪs]
#ʃ	74.16%	50% (1/2)	MARY'S SHOES ARE CLEAN [ˈmɛəɹi (.) ˈʃud ə ˈxlĩn]
Elision			
Ct#C	84.54%	50% (2/4)	SHE WRAPPED THE PARCEL [s̈i ˈwæp˺ bə˘ ˈpʰ as̈tʊ̈]
Cd#C	59.83%	70% (7/10)	HE SNEEZED VERY LOUDLY [hi ˈn.ĥid fəlɛ˘ ˈvɛwi ˈlaʊd̥ (.) li]
Liaison			
j-liaison	88.44%	25% (1/4)	THEY ARGUED ALL DAY [ði ˈʔagjʊ̈d ɔ deɪ]
w-liaison	93.47%	0% (0/2)	THE YELLOW AEROPLANE CRASHED [jɛ̰ː ə˘ḭ (.) ə ˈlɛləʊ (.) jɛləʊ (.) ʔɛʊəˈpleɪ˜n ˈkwæç̈ːt ']
r-liaison	88.36%	0% (0/4)	I WORE A JUMPER [aɪ ˈwɔ ə ˈʤʌ˜mpə]
Articles			
Indefinite	No norms given	0% (0/2)	SAM ATE AN ORANGE VERY SLOWLY [ˈθæ̈˜m ˈɛ̰ʔ ə ɒˈwɪ̰˜nʤ̥ fɛwi ˈləʊː.ˈli]
Definite	No norms given	0% (0/2)	SHE GAVE THE ORANGE TO SAM [ʃɪ̈ ˈgeɪv̥ ðə ˈɒwənʤ̈ ʧə ˈθ̈ æ˜m]

4.12.2 Word juncture in spontaneous, conversational speech

The word juncture pattern in conversational speech was different to that in the imitation task in that liaison was the most evident process, although there were very few word boundary contexts where assimilation or elision could have occurred. Examples of liaison include /j/-liaison in IT WAS ACTUALLY A BIG -SP-MONEY SPIDER [ɪʔ wəz̈. ˈæ˜ʔʃjiʲ ə˘ ˈbɪ˜ʔfŋ bə˘ ˈmʌ˜ni ˈm.b̥aɪdə] and /r/-liaison (realised as the glide [w]) in WE HAD TO COLOUR IN [wi ˈhɛk˺ tʰ ə˘ ˈkʰ ʌləʷ ɪ˜n].

In the few sites where elision and assimilation could potentially occur there were occasional instances of both. For example, word final consonant elision at a word boundary can be seen in the utterance I SAW IT LAST NIGHT realised as [aɪ ˈdɔʷ ɪʔ ˈla˜fŋ

⁀ʿ n͊aɪʔ]. Nasal turbulence was the main feature of this word boundary, spreading from the SFWF velopharyngeal segment to the SIWI alveolar nasal, with the word final /t/ in LAST elided. An example of assimilation was heard in conversation in A LION CALLED ALEX AND A HIPPO CALLE<u>D G</u>LORIA realised as [ə ˈlaɪə˜n ˈkɔd ˈælɪf͡ŋ æ˜n ə˘ ˈhɪpəʊ ˈkɔg⁀ ˈglɔɹijə]. The SFWF /d/ in CALLED was assimilated to a velar place of articulation before the SIWI velar /g/ in GLORIA. This contrasts with realisation of the previous /d/ in CALLED before the vowel in ALEX, and indeed the unassimilated SFWF alveolar nasal in LION next to the SIWI velar plosive in CALLED.

Overall Tallulah's speech at word boundaries showed more open than close juncture. This was particularly so between vowels in sentence imitation and so may be reflective of task effects, but was also evident to a lesser extent and with a different pattern in conversation. There were occasional instances of hyperelision, as seen in table 4.7 CAN YOU PLEASE SAY IT AGAIN realised as [xə˜˘n⁀pli⁀ ˈð͊eɪ ə (ə˘)ˈd̚ɛ˜n], but this was not characteristic of her conversational speech.

4.13 Prosodic characteristics

The prosodic organistion of Tallulah's speech was considered across all types of sampling conditions. The difficulties identified at the level of motor planning might be expected to have impact on the prosodic aspects of her speech output. Disturbances in prosody have been reported in children with CAS which is characterised by motor planning and programming deficits (Velleman, 2011) and although Tallulah had not been diagnosed with CAS, impaired motor planning might result in atypical prosody like that described in children who do have CAS. These descriptions include flat or monotone intonation (Davis et al, 1998) and inconsistent use of pauses and transitions between consonants and vowels (Peter & Stoel-Gammon, 2008) but primarily focus on impaired realisation of stress at a lexical and phase level (Gildersleeve-Neumann, Hammer & McCauley, 2008). In fact, observations of Tallulah's speech output did not reveal any such disturbances. She produced typical-sounding stress-timed speech with appropriate syllables made prominent by a combination of phonetic devices (Kohler, 2009), at times alternating with individual stretches of syllable-timed speech, similar to that of a child described by Howard (2004b). In terms of intonation her use of tonic placement and tonicity was unremarkable. Although not formally assessed, there were no observations of instances of unusual prosodic form or function (Wells & Peppé, 2001).

4.14 Summary of findings T1

Tallulah's input processing skills and speech output skills at T1 were summarised as follows: (see also her speech processing profile, appendix 4.2, and 4.3 for the mapping of this profile to the speech processing model).

- Input processing skills were in the typical range for her age
- The single real word naming task indicated severe difficulties with the production of words across all word lengths
- The non-word repetition task showed accuracy of production that was in the typical range for her age. Although the number of words correct for two syllable words indicated a level of difficulty this was specifically related to her realisation of /s/ clusters
- There was no evidence of oro-motor difficulties
- Tallulah's performance on the DDK task suggested that she had difficulties with motor planning
- Her phonetic inventory included all English consonant phones, a nasopharyngeal fricative and oral segments with nasal turbulence or audible nasal emission
- Her vowel inventory included all appropriate English vowels
- PCC was 70.82% and PVC was 95.41% (PPC of 83.11%) corresponding with a mild to moderate level of difficulty
- The most frequently occurring phonological process was cluster reduction and simplification
- Comparison of the three types of sampling conditions shows that the main difference between them in terms of segmental output was in the frequency of mature consonant cluster realisation, with those in her single words being more accurate than those in her conversational speech
- Nasal realisations of consonant segments /s/ and /z/ were a pervasive feature of Tallulah's speech

- Tallulah's production of multisyllabic words was noticeably impaired

- Her speech output revealed two sources of variability. One source of variability was related to positive change (i.e. variation between the adult target and Tallulah's realisations); the other appeared to be the result of attempts to modify output breakdown and did not necessarily result in more accurate speech

- Examination of word juncture suggested that the connected speech processes of assimilation and elision were emerging in the sentence imitation task but Tallulah used very little liaison; this was the opposite of data from conversational speech. Open juncture was more common than close juncture. She produced stretches of syllable-timed speech as well as more typical stress-timed utterances

- It appeared that Tallulah had difficulties with updating motor programmes and motor planning, and an awareness of possible interactions between phonological and phonetic learning early in her speech development are essential considerations in the explanation of the presentation of her speech

The impact of these difficulties on Tallulah's intelligibility as experienced by the listeners who participated in the study was explored.

4.15 Intelligibility T1

Tallulah's intelligibility was measured through listener responses to an orthographic write-down task for single words, imitated sentences and conversational speech (as described in the Chapter Three, Methods); results are presented in table 4.9. Stimuli from Tallulah's speech output that were presented for intelligibility rating and results for individual items are given in full in appendix 4.12 and in tables 4.14, 4.15 and 4.16.

Table 4.9 Tallulah: Intelligibility outcomes T1

Data type	Mean % (No.)	S.D. % (No.)	Minimum % (No.) score	Maximum % (No.) score
Single words (max no. = 11)	54.82 (6.03)	12.95 (1.42)	27.27 (3)	81.82 (9)
Imitated sentences (max no. = 22)	80.30 (17.67)	10.34 (2.27)	50 (11)	100 (22)
Conversational speech (max = 100%)	66.71	13.30	33.33	91.67

Analysis of the results using the Wilcoxon Signed Ranks Test demonstrated that the listeners' identification of Tallulah's single words was poorer than that of multi-word utterances. There were significant differences between SW and imitated sentences (Z=-6.850, p<.0001) and SW and conversational speech (Z=-5.494, p<.0001). There was also a significant difference between imitated sentences and conversational speech (Z=-5.756, p<.0001), in favour of imitated sentences.

All types of utterance show a wide range of listener responses, as evidenced by the minimum and maximum scores and the large standard deviations (see Table 4.9). In terms of the individual stimuli items, in SW FROG was least intelligible with only 2/66 listeners identifying it correctly; GIRAFFE was most intelligible with 65/66 correct responses. The least well identified imitated sentence was WE SAW (A) TENT BY (THE) RIVER with 50.30% of words identified correctly. The best identified were MY UNCLE IS (A) FARMER, 98.86% of words correctly identified, and I LIVE NEAR (A) BIG WOOD where 98.79% of words were correctly identified. In conversational speech WE USED SCISSORS LAST NIGHT was least intelligible, with 46.97% of words identified, compared to the longest utterance WELL ONE WAS IN MY DRAMA AND HE'S CALLED TOM where 81.96% of words were recognised. These intelligibility results are discussed in section 4.26.5.

4.16 Intervention T1 to T2

Between T1 and T2 (age 6;5 to 7;3 years) Tallulah received weekly speech and language therapy intervention during school terms, initially in school, but subsequently at home after school so that her mother could attend sessions and carry out follow-up activities. The order and focus of intervention activities was as follows:

- Awareness and discrimination of segments realised with oral and nasal airstream (single sounds, CV and VC syllables, CVC words)
- Sorting CVC words by initial consonant (contrast oral/nasal; plosive/fricative)
- Production of plural /s/ and /z/; a preceding alveolar plosive facilitated an oral airstream, for example, "hats", "beds"
- Production of /s/ clusters in single words and multi-word utterances
- Production of high frequency syntactic structures requiring /s/ and /z/ such as "it's a...", "there's a..."; "because it's..."
- Production of multisyllabic words which Tallulah used frequently, for example, yesterday, afternoon, reception
- A narrative approach to intervention to support the generalisation of skills

At the end of this period of intervention Tallulah's speech was reassessed.

4.17 Assessment T2 (CA 7;3)

Twelve months after the first assessment at T1 Tallulah's input processing skills and speech output skills in single words and multi-word utterances were reassessed (see appendix 4.13 for her updated speech processing profile and 4.14 for the mapping of this profile to the speech processing model). The aim of this reassessment was to collect sufficient data to describe any significant changes in Tallulah's skills and also to examine her intelligibility at T2 as judged by the listeners (see Chapter Three, Methods).

4.18 Input processing skills T2

The investigation of Tallulah's input processing skills included assessment tasks from Stackhouse, Vance, Pascoe and Wells (2007) and other non-standardised activities. Only one auditory discrimination task was repeated at T2, the same/different judgement of complex non-words (Stackhouse et al., 2007). At T1 Tallulah's score had been 77.5% overall, compared with a mean of 82.5% for 5-6-year-olds, z=-0.37. At T2 her overall score was 85%, compared with a typical score of 90.66%, again within the normal range, z=-0.75.

Tallulah's phonological awareness skills were reassessed using the assessment from the Sound Linkage Programme (Hatcher, 1994). At T1 her score was 66.66% (24/36); at T2 it was 72.22% (26/36), indicating few changes over the year (although no norms are given in the test). She was not consistently able to segment words into phonemes beyond CVC level, delete phonemes to create new words when required to segment a consonant cluster (for example, "take 's' away from 'stop'") or carry out a phoneme transposition task ("net" is reversed to become "ten"). Whereas at T1 she had responded quickly during these tasks, at T2 she required more repetition of the stimuli and at one point in the reassessment process remarked "I'm not good with words".

4.19 Speech output skills T2

Tallulah's speech production was re-assessed using a range of single word tests as at T1; the Picture Naming Task (Stackhouse et al., 2007) and subtests of the DEAP (Dodd et al., 2002) giving 100 items collected from these tasks for single word (SW) analysis compared with 112 at T1 (the DEAP Inconsistency Assessment was not repeated) (appendix 4.3). The non-word repetition task was not repeated. The multi-word data are from the analysis of T2 conversational speech (CS) (appendices 4.15 to 4.18) and selected imitated sentences from the Connected Speech Processes (CSP) Repetition Task (Stackhouse et al., 2007) (appendix 4.11); there are occasional examples from other conversational speech, which are indicated in the text.

Tallulah's performance on the Picture Naming Task (Stackhouse et al., 2007) was scored and compared to that expected in the speech of typical 7-year-olds; scores were also compared with T1 (see table 4.10). Tallulah's overall score was 49/60 (81.66%), z=-1.32, compared with 28/60 (46.66%), z =-5.53 at T1. This score is in the range expected for her age.

Table 4.10 Tallulah: Scores Picture Naming Task T1 compared with T2

Word structure	Tallulah's score T1 (z-score)	Tallulah's score T2 (z-score)	Norms age 7 years (mean, S.D.)
1 syllable (N=20)	9 (-7.13)	19 (0.833)	18.8 (1.20)
2 syllable (N=20)	8 (-6.33)	14 (-3.47)	18.45 (1.28)
3 & 4 syllable (N=20)	11 (-1.46)	16 (-0.40)	16.95 (2.33)
Total (N=60)	28 (-5.53)	49 (-1.32)	54.2 (3.93)

Although Tallulah's overall score at T2 was typical for her age, results indicated that production of 2 syllable words (14/20, z=-3.47) was still showing a significant level of difficulty in comparison to a peer group. Examination of the words produced showed that 5 of the 6 had minor immaturities or phonetic variations: SANDWICH realised as [ˈsæ̃mbɹɪʤ̊]; FEATHER [ˈfɛvə]; TRACTOR [ˈtʃɹækəɾə]; PARROT [ˈpʰ æʊʌtʼ]; SEESAW [ˈsɪ̆ʃɔ̆]. The exception to this was the realisation of DUSTBIN where the coda cluster in DUST was realised as a bilabial nasal with turbulence, preceding the bilabial plosive onset of BIN; [ˈdʌm̥.bɪ̃n]. This appeared to be a residual error in that this pattern of nasal turbulence immediately before a bilabial plosive had been a feature of Tallulah's speech at T1.

The overall percentage correct in the production of consonants and vowels in Tallulah's speech had changed by T2. At T2 her PCC was 91.47% (70.82% at T1) and PVC was 99.43% (95.41% at T1), giving a PPC of 95.55% (83.11% at T1). These scores indicated a mild severity rating (Shriberg & Kwiatkowski, 1982). There was no evidence that any delayed or unusual patterns were still consistently used, rather that her speech production showed remnants of the difficulties previously identified.

4.20 Oro-motor assessment and diadochokinesis (DDK) T2

It had previously been established that Tallulah did not have oro-motor difficulties. However, she continued to show difficulties in the production of a [p], [t], [k] sequence. Variations included [p] [k] [t]; [p] [t] [t] and spontaneously "pat-a-cake". This suggested that Tallulah continued to have underlying motor planning difficulties.

4.21 Phonological process analysis T2

A phonological process analysis was again completed using data primarily from single words and conversational speech, supplemented by data from imitated sentences.

4.21.1 Structural processes T2

All structural processes had resolved apart from occasional examples of SIWI cluster reduction. These occurred both in SW and multi-word utterances. For example:

1) CROCODILE (SW) realised as [ˈkʰ ɒkʰ ədɑʊ]; T1 realisation: [ˈɸwɒkxəgaɪʊ̃]

2) FROG (SW) realised as [fɒg] then on another occasion where the same stimulus was used as [fwːɒg]; T1 realisation: [f̬wɒg˺]

These types of simplification where the cluster was reduced to a single element also occurred in conversational speech, for example, FRUIT and STRAWBERRY in the utterance IT'S A FRUIT-UM- STRAWBERRY realised as [ˈʔɪtz ə ˈfut' ... ə˜m ˈstɹɔbi].

Tallulah's monitoring of these realisations appeared limited in that she rarely self corrected (although see example 2 below for one of those occasions when she did). For example, (CS4 T2) AND WE STAYED THERE FOR BURGER KING was realised as [ˈʔæ˜n wi ˈseɪd˺ ðɛː fɔ ˈbɜ˞ɡ̊ə͡ xɪ˜n]. There was no attempt to repair the reduced onset cluster realisation in STAYED.

Querying Tallulah's production resulted in repair attempts but these were not always immediately successful. In conversational speech there was some variability in cluster production demonstrated by different versions of the same lexical target (Example 1) or from what appeared to be difficulties in planning or phonological assembly of complex targets across word boundaries (Example 2).

Example 1: Target: SPIDER: realised in three different forms

Tallulah	SPIDER
	[ˈspaɪdə]
J	And what's this?
Tallulah	SPIDER WEB WHAT SPIDERS MAKE OF (?SILK)
	[ˈfaɪdə ˈwɛb wɒm̥͡ m̥baɪdəz ˈmeɪk' ɒv ˈsni]
J	Can you say that again?
Tallulah	UH-WHAT SPIDERS MAKE OF (??SILK)
	[(v) wɒʔ ˈspaɪdəz ˈmĕɪk ɒvɛ (ˈnjɪ‿ɛ)]

Tallulah's realisation of SPIDER as a SW matched the adult target; in her next production she was producing a linguistically complex multi-word utterance and first produced [f] which had not been common for /sp/ although there were other infrequent examples of coalescence at T1. She realised the next target /s/ as a bilabial nasal with turbulence. This segmental sequence when /s/ and /z/ were followed by a bilabial plosive was particularly vulnerable to nasalisation (as has already been noted). Her final realisation of the target was accurate; this was possibly aided by the request for repetition, although this request was actually focused on the final word in the utterance rather than "spider".

The next example was from the sentence imitation task and relates the SFWF clusters in the targets COLLECTS and STAMPS.

Example 2: JOHN COLLECTS STAMPS (NS 12)

Tallulah	JOHN COLLECTS STAMPS
	[ˈʤɒ˜ŋ kʰ əˈlɛps ˈstæps (.) ˈstæ˜mps̬]
J	Do that again
Tallulah	JOHN COLLECTS STAMPS
	[ˈʤɒ˜ŋ kʰ əˈlɛp (.) d̚ə˘ (.) ˈstæ˜ːps]
J	Is that a tricky word-collects- John collects stamps
Tallulah	JOHN COLLECTS STAMPS
	[ˈʤɒ˜ŋ kʰ əˈlɛks ˈstæ˜mps]
J	Well done

Tallulah's realisations of COLLECTS and STAMPS appear to be affected by assimilatory and simplification processes. Her first attempt showed apparent perseveration between the two SFWF clusters, although she then self-corrected. Her second attempt resulted in two separated segments being produced as the SFWF cluster in COLLECTS and omission of the bilabial nasal in STAMPS (although nasalisation of the vowel was realised). Her final attempt, after an adult model, resulted in an acceptable production.

4.21.2 Systemic processes T2

Systemic processes had also largely resolved by T2; there were still occurrences of fully devoiced final obstruents, for example, BIR<u>D</u> realised as [bɜt]; LEG<u>S</u> realised as [lɛgs]. Gliding of /r/ was common but variable, for example, THREE realised as [fwi] but RABBIT as [ˈɹæbɪt'].

The phonological process analysis indicated that Tallulah's speech difficulties were resolving, as had also been indicated by the results of her Picture Naming Test and PCC results. The next part of the analysis was designed to consider other aspects of Tallulah's speech output that had not been captured through the phonological process analysis.

4.22 Features not captured through phonological process analysis T2

As at T1, the phonological process analysis revealed a wealth of information which contributed to the description and explanation of Tallulah's speech patterns and intelligibility. However, a wider analysis was necessary in order to examine the other features such as the atypical nasal realisations which could not be accounted for through a traditional phonological process analysis approach. In addition the production of multisyllabic words, variability, and word juncture behaviours in multi-word utterances were explored.

4.22.1 Nasal realisations T2

By T2 the frequency of use of velopharyngeal fricatives and the occurrence of nasal turbulence or audible nasal emission had reduced considerably. In the SW data there were only two examples; DUSTBIN realised as [ˈdʌm̥b͋ɪ˜n] and HOSPITAL realised as [ˈhɒ˜m̥p͋˭ ɪtəʊ]. This pattern where the target "alveolar fricative followed by bilabial plosive" was particularly vulnerable to nasal turbulence was mentioned at T1, and at T2 was still found in conversational speech (CS 4 T2) where Tallulah was talking about HOSPITAL as [ˈhɒm̥p͋˭ ɪtʊ̰]. This occurred also in connected speech across word boundaries, for example, in THAT OTHER ONE WHAT'S BIG WHO SQUEEZE YOU [ˈðæʔ ʌv ˈwʌ˜n wɒm̥͋ ˈbɪɡ hʊ ˈskwiʒ ˈju], SFWF /s/ was realised as a voiceless bilabial nasal with turbulence before the bilabial plosive [b] (see table 4.11).

Table 4.11 Tallulah: Examples of nasal turbulence in multi-word speech T2

NS 33	THE TOY ELEPHANT WAS BROKEN
	[ðə ˈtɔɪ ˈʔɛləfəñʔ wɒm̥͋ˈbɹəʊkə˜n]
CS 2	THAT OTHER ONE WHAT'S BIG WHO SQUEEZE YOU.
	[ˈðæʔ ʌv͡ ˈwʌ˜n wɒm̥͋ ˈbɪɡ hʊ ˈskwiʒ ˈju]

There were occasional other instances of nasal realisations; for example, in naming SCHOOL (SW) she said BORING SCHOOL realised as [bɔwɪŋ̊ ŋ̊k͋ˇuʊ] but the most persistent examples were in the phonetic context already described.

4.22.2 Multisyllabic words T2

Tallulah's production of multisyllabic words was still, at times, atypical. This appeared to be influenced by segmental complexity and possibly lexical familiarity. Some examples are given below:

1) NS 19: target HE JUDGED THE COMPETITION [hi ˈdʌʤ ðə ˈʧɒbəˈkɪʃə˜n]. In this imitated utterance, the SIWI voiceless velar plosive has been realised as a voiceless post-alveolar affricate, suggesting the long domain harmony from the influence of the SIWI voiced post-alveolar affricate in the word JUDGED. The bilabial SFWW nasal and SIWW voiceless plosive have been replaced by a single bilabial voiced plosive which assimilated features of both adult targets (i.e. voice plus plosive). The

voiceless alveolar plosive has been backed to a velar placement and the final syllable matched the adult model.

2) SW target <u>AVOCADO</u>: (NB: This item was produced as a response to a request to name a picture of a strawberry). In this example the first consonant, a SIWW voiced labiodental fricative, was realised as a voiced bilabial plosive; the second consonant, a SIWW voiceless velar plosive, was fronted; the third consonant, a SIWW voiced alveolar plosive, was realised as a voiceless alveolar plosive. Her immediately following repair attempt resulted in an accurate realisation of velar plosive but not the other consonants.

Tallulah	ORANGE
	[ˈʔɒʊɪ˜nʤ]
J	No
Tallulah	AVOCADO-AVOCADO IT'S A FRUIT
	[ʔæbʊˈtʰ ɑtʰəʊ̤ (.) æbəˈkʰ ɑtʰ əʊ (.) ˈʔɪtz ə ˈfut']
J	Avocado- no- this is something else
Tallulah	UM-STRAWBERRY
	[ə˜m ˈstɹɔbi]

3) Tallulah's spontaneous production of BOA CONSTRICTOR (CS 1 T2) was imprecise with reduction in the number of syllables and a corresponding loss of segmental information which might present difficulty to a listener.

Tallulah	A BOA CONSTRICTOR-ONE CAME TO OUR SCHOOL
	[ə ˈbʊ˜st̚ ɹɪ˜kt̚ ə ˈwʌ˜n ˈkʰ eɪ˜m tʰ ə ɑ ˈskuʊ̰]
J	Listen to that - boa constrictor
Tallulah	BOA CONSTRICTOR
	[ˈbə˜ʊn ˈkɒ˜n̩t̚ ɹɪkdʌ]

Her initial realisation suggested that the motor programme for this low frequency item was not fully specified and the adult model improved this with her imitated production showing more precision and phonetic detail.

As in the phonological processes, the examples of nasal realisations and difficulties with multisyllabic words were greatly reduced at T2. However, her ongoing variability, especially with lower frequency vocabulary, was suggestive of motor programming problems interfering with the establishment of accurate motor programmes.

4.22.3 Variability T2

Although at T2 there was still evidence of segmental variability (as seen in some of the previous examples) this had decreased considerably and it was no longer a major feature of Tallulah's speech. However, in complex linguistic environments (again as seen in previous examples) Tallulah's skills were still fragile and at times this negatively affected the acceptability and intelligibility of her word production.

4.23 Word juncture in multi-word utterances T2

As at T1, Tallulah's use of assimilation, elision and liaison, and close versus open juncture was examined in sentence repetition and in conversational speech. This was first explored using the Newton Sentences Connected Speech Processes (CSP) task (Stackhouse et al., 2007), (see table 4.12). Results were compared to those of other 7-year-olds and to Tallulah's scores at T1.

Table 4.12 Tallulah: Scores on the Connected Speech Processes (CSP) Repetition Task T1 and T2

	Tallulah 's score T1	**Tallulah 's score T2**	**Score expected at age 7**
Assimilation			
t#	75%, (3/4)	50% (2/4)	92.40%
n#	50% (2/4)	50% (2/4)	80.43%
d#	100% (4/4)	100% (4/4)	43.18%
#ʃ	50% (1/2)	100%(2/2)	83.83%
Elision			
Ct#C	50% (2/4)	25% (1/4)	86.94%
Cd#C	70% (7/10)	30% (3/10)	72.63%
Liaison			
j-liaison	25% (1/4)	50% (2/4)	91.49%
w-liaison	0% (0/2)	50% (1/2)	95.35%
r-liaison	0% (0/4)	25% (1/4)	86.15%
Articles			
Indefinite	0% (0/2)	0% (0/2)	No norms given
Definite	0% (0/2)	0% (0/2)	No norms given

Tallulah's use of assimilation was essentially unchanged but it is difficult to draw conclusions about her use of elision in these examples which appeared to be less well developed than at T1. More positively, different forms of liaison, of which there had been little evidence at T1, were now being used in this sentence repetition task, thus more closely matching patterns seen already in conversational speech. However, as at T1, Tallulah's word boundaries were still often realised with open juncture and this was perhaps reflective of the perception that she took a sometimes careful approach to the imitation task as described in section 4.12.1. There were a few instances where she repeated the stimulus items either in response to an adult request or to self-correct. Her repeated realisation usually showed some differences at word boundaries. Two examples are given below:

1) Target: elision THEY ROBBED THE BANK YESTERDAY. Tallulah's first production was: [d̚ə˘ ˈwɒd̜(.) də ˈbæ˜ŋʔ ˈjɛn̥.t͋ʰ ədeɪ]. When asked to repeat the sentence to repair the nasal turbulence in YESTERDAY, her second production was: [deɪ ˈwɒb.d. (.) ðə ˈbæ˜ŋk (.) ˈjɛstʰ ədeɪ]. In the first example, there was a pause between ROBBED and THE, and elision of the voiced bilabial plosive in ROBBED. In the second example, close juncture was used between the pronoun and verb (THEY ROBBED) and determiner and noun (THE BANK) but other word boundaries were delineated by pauses (although this may have facilitated the realisation of the SFWF velar plosive in BANK). This may have allowed more planning time for Tallulah to plan the production of YESTERDAY (and indeed ROBBED) which were arguably more complex segmental sequences.
2) Target: assimilation THE BROWN BEAR EATS FISH. Tallulah's realisation: [ˈbɹaʊ˜m bɹɛə (.) m̥͋ ˈbɹaʊ˜n (.) ðə ˈbɹaʊ˜n (.) ˈbɛə (.) ˈit' (.) ˈvɛ‿ʃ]
   In her first production Tallulah used appropriate assimilation at the word boundary between BROWN and BEAR, but she also perseverated on the initial consonant cluster of BROWN, producing it again for the onset of BEAR. She recognised the error and attempted a repair (producing a short burst of nasal turbulence as she did so). She used close juncture between the determiner and adjective (THE BROWN) but open juncture through the rest of the utterance so that the assimilation was then not produced.

In conversational speech there was some evidence of close juncture with assimilation and liaison processes occurring. For example: ONE OF THOSE BIG ONES WHAT SQUEEZE YOU realised as [ˈwʌ˜n ə ðəʊz̥ ˈbɪg ˈwʌ˜nz̥ wɒʔ ˈskwiʒ ju], showed anticipatory post-alveolar assimilation. In the utterance I HAVE (TO) DO IT BY NAILS Tallulah used both [j] and [w] liaison appropriately in intervocalic contexts: [ˈʔaɪʲ a‿z ˈd̪uʷ ɪʔ ba‿ɪ ˈneɪʊz]. Unlike sentence imitation where the pattern of open juncture was pervasive, Tallulah's conversational speech was more typical in that close juncture forms predominated.

However, opportunities for assimilation and elision at word boundaries were limited by lexis and grammar, with for example, very few instances of regular past tense endings.

In Tallulah's conversational speech there were examples of appropriate phonetic reduction in multi-word utterances. For example (CS 1 T2) CAN I TELL YOU SOMETHING was realised as [ˈkʰ aɪ ˈtɛ jə ˈsʌ˜mfɪ˜ŋ] with CAN and I reduced to a single form. However, on occasion, this hyperelision impacted on intelligibility. For example, (CS 4 T2) I WAS A TINY LITTLE BABY IN MUMMY'S (?TUMMY BUTTON) realised as [ə wəʔ ə ˈtʰ aɪni lɪə ˈbeɪbi ɪ˜n ˈmʌ˜miz̩ (ˈtʰ əʊɪə˜nʔ)]. The final words in the utterance were unclear but from segmental and contextual cues were interpreted as TUMMY BUTTON.

4.24 Summary of findings T2

Assessment at T2 demonstrated evidence of changes in Tallulah's speech production. This was shown through PCC with a score of 91.47%, compared with 70.82% at T1, and in single word naming where the overall score was in the range typical for her age. However, her speech output was still affected by minor phonetic differences and infrequent but persistent structural phonological processes, in particular cluster reduction. Atypical patterns of nasal airflow and turbulence were much reduced in frequency but still occurred, particularly in phonetically vulnerable contexts.

Tallulah continued to have difficulties with motor planning, as evidenced by the DDK task. Complex sound sequences were still vulnerable to breakdown, as seen at times in multisyllable words and instances of hyperelision in multi-word utterances. This was also reflected in use of open juncture in the sentence imitation task. However, overall she could be classified by this point as having a mild level of difficulty and she was producing stretches of conversation which sounded entirely typical for a child of her age.

This leads to the exploration of the impact of these changes on Tallulah's intelligibility as experienced by the listeners who participated in the study.

4.25 Intelligibility T2

Tallulah's intelligibility at T2 was measured in the same way as at T1 (see Chapter Three, Methods). The same 10 SW and 5 imitated sentences recorded at T1 were recorded again at T2 and edited for the intelligibility task; the conversational speech samples from T2 were obviously different. Results for T1 and T2 were compared (see table 4.13).

Analysis of results using the Wilcoxon Signed Ranks Test (see table 4.13) demonstrated that the listeners' recognition of Tallulah's single words had improved significantly (Z=-4.494, p=<.0001). Results for conversational speech also showed significant improvement (Z=-7.056, p=<0001). Conversely, intelligibility of imitated sentences had slightly worsened and this difference was significant (Z=-3.350, p=<.001). The significant difference between SW and imitated sentences demonstrated at T1 had reduced (Z=-2.343, p<.019). The difference between conversational speech and imitated sentences had changed significantly favour of conversational speech (Z=-6.993, p<.0001). The difference between SW and conversational speech remained significant (Z=-6.979, p<.0001) with conversational speech being the best identified type of utterances.

The range of listener responses remained very wide for all types of stimuli, for example, one listener (L9) recognised only 2/11 SW and one (L55) understood all 11 words. Overall, conversational speech was the most intelligible type of utterance and although one listener (L63) only identified 54.55%, 12/66 listeners correctly identified all of the utterances.

Table 4.13 Tallulah: Intelligibility outcomes T1 compared with T2

Data type	**T1 Mean % (No.)**	T1 S.D. % (No.)	T1 Min score % (No.)	T1 Max score % (No.)	**T2 Mean % (No.)**	T2 S.D. % (No.)	T2 Min score % (No.)	T2 Max score % (No.)
Single words (max no. = 11)	**54.82 (6.03)**	12.95 (1.42)	27.27 (3)	81.82 (9)	**66.25 (7.29)**	18.54 (2.04)	18.18 (2)	100 (11)
Imitated sentences (max no. = 22)	**80.30 (17.67)**	10.34 (2.27)	50.00 (11)	100 (22)	**74.79 (16.45)**	14.35 (3.30)	36.36 (8)	95.45 (21)
Conver-sation (max = 100%)	**66.71**	13.30	33.33	91.67	**92.70**	8.12	54.55	100

Responses to individual items also varied. In SW (see table 4.14) THUMB was least well recognised (7/66) and SOCK was most intelligible (57/66). These items were both different to those least and best recognised at T1.

Table 4.14 Tallulah: Analysis of individual single words from intelligibility task T1 and T2

Word	Adult target	**Tallulah 's realisation T1**	Number of words identified by individual	**Tallulah 's realisation T2**	Number of words identified by individual

			listeners T1		listeners T2
BISCUITS	/ˈbɪskɪts/	[ˈbɪ θ̃ɧ̃ k̚ ɪʔɧ̃]	98/132*	[ˈb̥ʰ ɪsk̚ ɪts]	110/132*
BREAD	/bɹɛd/	[bwɛd̥]	11/66	[bɹɛd̥]	46/66
DUCK	/dʌk/	[dʌ̰k']	57/66	[dʌk']	31/66
FROG	/fɹɒg/	[f̩wɒg̚]	2/66	[fɒg]	49/66
GIRAFFE	/ʤəˈɹɑf/	[ʤəˈʋɑf]	65/66	[ʤə̆ˈɹɑf]	51/66
MONKEY	/ˈmʌ̃ŋki/	[ˈmʌ̃ŋki]	60/66	[ˈmʌ̃ŋki]	42/66
QUEEN	/kwĩn/	[kwiə̃n]	19/66	[kwĩn]	39/66
SOCK	/sɒk/	[ɧ̃ɒ̃k']	14/66	[sɒk]	57/66
THUMB	/θʌ̃m/	[fʌ̃m]	21/66	[fʌ̃m]	7/66
ZEBRA	/ˈzɛbɹə/	[ˈdɛbwə]	51/66	[ˈzɛbɹə]	49/66

*Score for BISCUITS calculated as 1 for the lexical item and 1 for the plural morpheme

In sentence imitation (see table 4.15) JOHN PLAYED TENNIS was least intelligible (42.05%), a change from T1, and MY UNCLE IS (A) FARMER (100%) was most intelligible as it had been at T1. To measure how well MWU were recognised the total number of words in each utterance was multiplied by the number of listeners and the percentage of correctly identified words was calculated (see table 4.15 and 4.16).

Table 4.15 Tallulah: Analysis of individual imitated sentences from intelligibility task T1 and T2

Target sentence	Tallulah 's realisation T1	Percentage of words recognised by individual listeners T1	Tallulah 's realisation T2	Percentage of words recognised by individual listeners T2
I LIVE NEAR (A) BIG WOOD	[aɪ ˈlɪv nɛ (.) ˈnɛː ə ˈbɪg ˈwʊd̥]	98.79%	[aɪ̆ ˈlɪv̥ nɛ ə ˈbɪg̊ (.) ˈwʊd̥]	76.06%
JOHN PLAYED TENNIS	[ˈʒɒ̃n (.) ˈpleɪd (.) ˈtʰ ɛ̃nɪʔːts̬]	95.45%	[ˈʤɒ̃nn ˈpleɪd ˈtʰ ɛ̃nɪs̬]	42.05%
MY UNCLE IS (A) FARMER	[maɪ̃ ˜ˈʔʌ̃ŋk ͡əz̥ ə ˈfɑ̃mə]	98.86%	[maɪ̃ ˜ˈʔʌ̃ŋkl̥ ɪz̥ eɪ ˈfɑ̃mə]	100%
THIS SHAPE IS (A) SQUARE	[ðɪʃ ˈʃeɪp ɪð̃ ə̃ ˈθw̃ɛə]	60.98%	[ðɪʃ ˈʃeɪp ɪz̥ ə ˈskwɛə]	87.88%
WE SAW (A) TENT BY (THE) RIVER	[wi ˈtɔ̰ʷ ə ˈtʰ ɛ̃n̪t̚ ə baɪ ðə {f ˈwɪvəː f}]	50.30%	[wi ˈsɔ̰ ʔɛɪ ˈtʰ ɛ̃nʔ baɪ də̆ ˈɹɪvæ̆]	65.45%

In conversational speech (see table 4.16) at T2 the least well-recognised utterance was ONE OF THOSE CAME TO OUR SCHOOL (84.85%) with A VERY NICE FISH being the best (100%).

Table 4.16 Tallulah: Analysis of conversational speech samples from intelligibility task T1 and T2

Target sentence	**T1 or T2**	**Tallulah's realisation**	**Percentage of words identified by individual listeners**
BUT IT DIDN'T FALL OVER	T1	[bə ʔɪʔ ˈdɪ˜əɱ ˈfɔɫ əʊvə]	61.87%
I (EH) WAS DRAWING (A) PICTURE IN (UM) BOBBY'S HOUSE	T1	[ˈʔæɛ͡ɪː wə˜m̥ ˈbɔwɪ˜n ə ˈpʰ ɪʔʧə ˈɪ˜ːnə˘̰ (.) ̰ɛ˜m (.) ˈbɒbĩfŋ ˈhaʊ˜fŋ]	72.54%
MAYBE IT'S JUST (A) PAPER	T1	[ˈmɛbiʔ z̥ ˈd̻z̥əs̻t ə ˈpʰ eɪˈpʰ ɐ̰ː]	53.33%
WE USED SCISSORS LAST NIGHT	T1	[ˈwi ju ˈs̻ɪ˜z̻ət fɑ˜s̻ ˈʔ͡naɪʔːʰ]	46.97%
WELL ONE WAS IN MY DRAMA AND HE'S CALLED TOM	T1	[ˈwɛʊ̰ ˈwʌ˜n wəz ˈɪ˜m͡ maɪ˘ ˈbwɑ˜̰mæ̰ æ˜n ˈhĩfŋ ˈkʰ ɔːt' ˈt̤ʰ ɒ˜̰ːm]	81.96%
(A) VERY NICE FISH	T2	[ə ˈvɛʋi ˈnaɪs ˈfɪ̰ʃː]	100%
ON MY BODY I HAVE FIVE LEGS	T2	[ˈʔɒ˜n maɪ ˈbɒdi ˈʔaɪ hæv (...) ˈfaɪv ˈlɛgz̥]	97.92%
ONE OF THOSE CAME TO OUR SCHOOL	T2	[ˈwʌ˜n ə ˈðəʊz ˈkʰ eɪ˜m tʰ əʷ ɑ ˈskṵʊ]	84.85%
THAT'S ONE OF THOSE BIG ONES WHAT SQUEEZE YOU	T2	[ðæts (.) ˈwʌ˜n ə ðəʊz̥ ˈbɪg ˈwʌ˜nz̥ wɒʔ ˈskwiʒ ju]	94.39%
THAT'S SIGN LANGUAGE	T2	[ˈðæts ˈsaɪ˜l͡ læ˜ŋwɪʤ̊]	88.26%

Following the detailed study of Tallulah's speech output and intelligibility, the research questions were considered in relationship to the findings. The discussion is focused mainly on findings from T1 unless otherwise indicated, apart from section 4.26.6.

4.26 Discussion

The aim of this chapter has been to give a detailed description and analysis of Tallulah's speech, and to consider the impact of her speech production difficulties on her intelligibility as judged by a group of adult listeners. At T1 at the age of 6;5 years Tallulah's PCC was 70.82% and on the Picture Naming Task (Stackhouse et al., 2007) she produced only 28/60 whole words (46.66%) with no errors (z-score of -5.53), so on both of these quantitative measures her speech was less accurate than that expected of a typical six-year-old. These findings corresponded with a significant level of difficulty. Tallulah could therefore legitimately be included in that group of children described as having "persisting speech difficulties" (Pascoe et al., 2006).

4.26.1 What will the detailed perceptual phonetic analysis of Tallulah's speech at word level reveal in terms of a traditional phonological process analysis (PPA)? What features are not captured through a traditional PPA?

4.26.1.1 Phonological process analysis

The examination of Tallulah's speech first focused on a phonological process analysis in line with the most common approach taken in clinical settings (Skahan et al., 2007), although this current analysis included information from both SW and MWU, thus drawing on wider samples of data than those derived from the naming tests routinely used in clinical practice.

4.26.1.1.1 Structural analysis

Cluster reduction was the most pervasive process in terms of frequency of occurrence and potential for impact on intelligibility because of changes to word structure (Weston & Shriberg, 1992; Yavas & Lamprecht, 1988). Tallulah's realisation of consonant clusters was poor with only 25.8% of word-initial and within-word productions in single words matching the adult target. SIWI and SIWW clusters in conversational speech were realised with a much lower rate of accuracy (15.38%) suggesting that she had difficulty in using mature patterns in the complex phonetic and phonological environment of multi-word utterances.

Tallulah had atypical realisation of oral fricatives in /s/ clusters (nasal realisations are discussed in section 4.26.1.2), but another slightly unusual feature of her consonant clusters was her production of some /r/ clusters. This involved a labial realisation of the adult targets and was a pattern which affected 4/14 targets in the SW sample and also occurred in MWU. These instances did not typically involve a simple reduction to one element, although they could as in the realisation of [tɹ] in <u>TYR</u>ANNOSAURUS REX (CS 6) as [ˈpʰ aɪ˜nˈfŋ ɔɹəs̈ː ˈwɛks̃]. More usually targets were produced in a variety of ways with bilabial realisation of alveolar and velar targets, and production of non-English bilabial fricatives. For example, CROCODILE realised as [ˈɸwɒkxəgaɪʊ̃]; PRAM as [p͡ɸwæ˜n]. This second example is interesting because /pr/ might have been an achievable target for her, given that she used both [bɹ] in [bɹʌʃː] and [pl] in [pleɪn], instead of which the transition from the first element [p] to the immature [w] included the production of a bilabial fricative. This output pattern may have been perceived as a segmental immaturity but an alternative view would be that it was a phonetic by-product of an imprecise articulatory gesture. If this interpretation is accepted, it is supportive of the argument that her atypical output was related to motor planning difficulties. It may be the case more generally that labial realisation potentially simplifies the motor planning demands of the complex segmental sequences in consonant clusters. Lip rounding for /r/ is a visually and perceptually salient feature and bilabial sounds appear early in development and require less differentiated motor patterns than other sounds (Moore, 2004). Tallulah had immature motor skills (as her DDK performance indicated) so by reducing the degree of lingual involvement (as required for velar plosive segments in CROCODILE for example) labial realisation of /r/ clusters would be an optimal solution to manage articulatory constraints.

4.26.1.1.2 Systemic analysis

Systemic phonological processes such as velar fronting arguably had less impact than structural ones because they occurred less frequently (Klein & Flint, 2006) or because the difference was phonologically less salient, such as gliding of /r/ to [w]. Evidence from Tallulah's clinical notes showed that her speech patterns were maturing. However, at T1 she was 6;5 and had been accessing intervention for three years; Shriberg (1997) states that 75% of children with speech delay have achieved normal output by the age of six. Although Tallulah's systemic processes were not unusual in the population of children with speech difficulties (Bowen, 2009), they nevertheless represented a significant difference in comparison with a group of typical peers.

4.26.1.2 Features not captured through phonological process analysis

Other than identifying the persisting nature of the difficulties, based on the available literature (Bowen, 2009; Grunwell, 1987; Williams et al., 2010) phonological process analysis did not reveal any patterns in Tallulah's speech that were particularly remarkable or unexpected in that the structural and systemic processes shown by Tallulah and described in the previous section are commonly reported in children who have speech difficulties. However, Tallulah's nasal realisation of alveolar fricatives was both an unusual and pervasive feature. A traditional phonological process analysis would lead to this pattern being categorised as atypical, however, it does not conform to the core concept of naturalness in the approach. It could therefore be argued that the phonological process approach could not adequately accommodate this major element of Tallulah's speech output.

4.26.1.2.1 Nasal realisations

From the first observation session with Tallulah a striking feature of her speech was the nasal realisation of alveolar fricatives. Later analysis showed that the most common segmental pattern was the velopharyngeal fricative. However, other realisations were observed, namely oral alveolar or dental fricatives accompanied by nasal turbulence and occasionally alveolar or dental fricatives accompanied by nasal emission. There were occasional examples of long domain hypernasal resonance in multi-word utterances.

These types of nasal realisations are the result of different articulatory gestures. The velopharyngeal fricative replaces alveolar or post-alveolar targets and results from stricture between the velum and the pharyngeal wall, with air being forced into or through the nasal cavity creating turbulence. Nasal turbulence has been described as a "snorting" sound, (Henningsson, Kuehn, Sell, Sweeney, Trost-Cardemone & Whitehill, 2008, p. 7), although this terminology is becoming obsolete (Howard & Lohmander, 2011). Nasal turbulence may also accompany a target realised with appropriate oral placement and manner, typically high-pressure consonants (plosives, fricatives and affricates). Nasal emission is defined as "an audible escape of air through the nasal passage" (Henningsson et al., 2008, p. 7) which also accompanies a target produced with appropriate oral placement. Hypernasal resonance is the result of incomplete velopharyngeal closure (Wyatt, Sell, Russell, Harding, Harland & Albery, 1996) which is perceived primarily on vowel segments.

In children who have typical speech development, the oral-nasal contrast emerges early and without difficulty (Speake & Howard, 2012). Atypical nasal airflow and resonance are particularly associated with cleft palate and velopharyngeal dysfunction (Henningsson et al., 2008; Howard, 1993; Sell, Harding, & Grunwell, 1994). These atypical patterns have also been reported in speech associated with other difficulties with an organic origin, for example, hearing impairment/deafness (Stevens, Nickerson, Boothroyd, & Rollins, 1976), post-adenoidectomy (Andreasson, Leeper, & MacCrae, 1991) and dysarthria (Dagenais et al., 2006). There was no evidence to suggest that there was any organic cause for Tallulah's nasal realisations.

There are also accounts in the literature of children who have atypical nasality patterns which do not have an organic basis but are associated with CAS, although these accounts are quite few in number. Stackhouse and Snowling (1992) describe "Caroline", aged 11;9 who had "fluctuating nasal quality indicating vocal tract incoordination" (p. 38). Davis, Jakielski and Marquardt (1998) report on "S1" aged 5;9 who had "difficulty in controlling velopharyngeal closure in connected speech, as evidenced by mild hypernasality" (p. 41). Given the pervasive effects of motor planning difficulties that may occur in CAS, difficulty in coordination of velopharyngeal movement is not unexpected.

Atypical nasal patterns may also occur in children who have phonological disorders, where nasal realisation of segments is associated with velopharyngeal mislearning (Trost-Cardamone, 1989). Ball, Manuel and Muller (2004) describe "Thomas" aged 3;10 who had significant hypernasal resonance on most but not all words. They report that he produced the majority of segments with velar placement, (with atypical contact between the tongue back and velum) and a lowered velum. However, he realised a small number of high frequency words in a typical way and the authors characterise his speech system as demonstrating phonological mislearning at an early stage of speech development.

This concept of phonological mislearning (and the use of an active nasal fricative to signal distinctions between segments) was explored by Harding and Grunwell (1998) who, in describing children with cleft palate, report that some:

> "apparently respond to a subconscious awareness of their limited phonetic and phonological repertoire by actively employing non-native sounds from their phonetic repertoire in order to maximise their range of meaningful contrasts" (p. 330)

They report that this pattern may occur in children who do not have cleft palate and that Trost-Cardamone (1990) refers to it as "phoneme specific nasality" (p. 334). However, this does not seem to be a mainstream issue as three recently published books focussing on intervention for speech sound disorders (Bowen, 2009; Rvachew & Brosseau-Lapre, 2012; Williams et al., 2010) make almost no reference to any type of abnormal nasal resonance or airflow patterns.

Notes in Tallulah's case history indicated that this feature of atypical nasality had emerged early in her speech development, having been noted at her initial assessment at age 2;2. Emergence at this time could feasibly be attributed to difficulties with motor planning if at the stage where Tallulah needed to use frication contrastively, she was not able to produce oral fricatives. Her solution was to use nasal turbulence "in order to maximise (her) range of meaningful contrasts" (Harding & Grunwell, 1998, p. 330). This mislearned phonetic and phonological pattern suggests an active search for solutions to output limitations similar to that described in relation to Tallulah's realisation of consonant clusters.

The perceptual impact of Tallulah's nasal turbulence was striking, and besides any effect on intelligibility, the turbulence impacted on the acceptability of her speech. Whitehill, Gotzke, and Hodge (2011) describe acceptability in terms of an outcome parameter "closely associated but not synonymous with intelligibility" (p. 294). They give a definition from Witzel (1995) stating that acceptability is "the subjective impression of the pleasingness of speech" (p. 147). Acceptability has relevance to social interaction and self-esteem and is an essential consideration in intervention. In the literature relevant to children's speech acceptability has been particularly explored in relation to cleft palate (Henningsson et al., 2008), but is not mentioned in recent text books on speech sound disorders in children (Bowen, 2009; Rvachew & Brosseau-Lapre, 2012; Williams et al., 2010). This is a concept that could usefully be examined in a broader way for children with a range of speech difficulties; for example, pervasive glottal stops affect intelligibility but arguably might also affect the "pleasingness" of speech, as might prosodic disruptions. For children with cleft palate speech acceptability is considered in target setting and decisions about whether intervention is offered. This is not obviously common practice with children who have speech difficulties which are not associated with cleft palate.

4.26.2 What does comparison of the patterns in Tallulah's speech data reveal across three speech elicitation conditions (1: single word production; 2: connected speech in sentence imitation; 3: connected speech in spontaneous conversation)

Comparison of the three types of sampling conditions shows that the main difference in Tallulah's segmental output was in the frequency of mature consonant cluster realisation, with those in single words being more accurate than those in conversational speech. This would suggest that Tallulah's ability to manage the production of consonant sequences was affected by the complex phonetic environment of multi-word utterances. However, the accuracy of those in imitated sentences was more like SW than conversational speech. This might strengthen the suggestion that processing load was a factor in the production of complex sound sequences in conversation, since repetition of heard sentences does not require the same lexical and syntactic resources as spontaneous speech. Another factor, perhaps more important, may have been her greater use of open juncture in the repetition task, allowing more planning time for word production. It was also noted that weak syllable deletion within words only occurred in conversational speech suggesting that the phonetic complexity of the environment of multi-word utterances might again be a factor.

Another difference between single words and multi-word utterances was in the production of multi-syllabic words. In SW naming Tallulah's realisations showed differences to the adult target which were generally predictable through the segmental analysis, but in conversational speech productions words of 3 or more syllables showed greater variability in both structural and segmental aspects. For example, STEGOSAURUS (CS 6) realised as [ˈkʰ ɛçkɔɟ]. Typically developing children make occasional errors in polysyllabic words (defined as 3 or more syllables) up to the age of 11 years (James, van Doorn, & McLeod, 2008). Children who have speech difficulties make more errors (*ibid*) as did Tallulah; they are also reported to make different errors, for example, metathesis which rarely occurs in the production of typical children (*ibid*), although Tallulah did not show instances of this. Her realisations of longer words showed persisting phonological processes and phonetic variation occurring with greater frequency in MWU. These observations support the view that speech assessment must include description and analysis of multisyllabic words in conversation.

The inclusion of the different types of sampling conditions therefore, revealed phonetic, phonological and prosodic information which was not evident from the SW data alone. Another such set of observations related to word juncture in MWU. In conversational speech at T1 Tallulah's word juncture showed examples of typical liaison but there were few clear examples of assimilation or elision at word boundaries because the opportunities for this were limited by lexical and grammatical factors. For example, she rarely used verbs requiring regular past tense morphemes which would have been realised in some phonetic contexts with elision in typical adult speech. In those few that occurred she usually used open juncture. For example in HE'S CALLED TOM the boundary between CALLED and TOM would typically be realised with elision of the past tense morpheme but Tallulah realised it not only with open juncture but with an ejective plosive in the SFWF position in CALLED [ˈhĩɦ̃ŋ ˈkʰ ɔːtʼ ˈt̤ʰ ɒ̰̃ːm]. She did sometimes use close juncture and immediately before this last example she had used assimilation of a SFWF alveolar nasal to a bilabial nasal in the utterance IN MY DRAMA realised as [ˈɪ̃m͡ maɪ̆ ˈbwɑ̰̃mæ̰]. However, open juncture was frequent and at times she alternated between stress-timed and syllable-timed speech, with open juncture predominating in stretches of syllable timed utterances.

Tallulah's use of open juncture was even more marked in the sentence imitation task where, contrary to conversational speech, there was very little evidence of liaison and her pauses were perceptibly longer, as in JOHN (pause) PLAYED (pause) TENNIS realised as [ˈʒɒ˜n (.) ˈpleɪd (.) ˈtʰ ɛ˜nɪʔːts̬] and JANE MADE SOME (pause) SOUP (said twice) realised as [ˈʤeɪ˜n ˈmeɪd ˈθ̃ʌ˜m̰ (.) ʃupfŋ̩ ˈs̃ʝũp' t']. This could be explained as a task effect, as Tallulah was repeating words and structures which she might not use in her own output, but also because she was a child who had had several years of speech and language therapy. It is interesting to reflect on what effect this might have in such assessment tasks and children's perspectives on why they might be asked to repeat in this way. If Tallulah's (accurate) view was that this was to test her speech output she might respond by attempting "best speech" (Klintö, Salameh, Svensson, & Lohmander, 2011) with open juncture concomitant with having time and space in which to do this. Thus her response to the task appears to reflect her awareness of the need to focus on her speech output, where focus can be described as "attention, motivation and effort" (Kwiatkowski & Shriberg, 1998, p. 28) in order to effect positive change.

4.26.3 Does Tallulah's speech output show phonetic variability within different speech elicitation conditions?

Throughout the analysis it was noted that there was considerable phonetic variability in Tallulah's speech. Sometimes this was progressive (Tyler & Lewis, 2005), with production varying between immature productions and the mature adult form. Sometimes, however, it appeared to be related to complexity, not only of the phonetic environment but also of the broader linguistic demands of MWU, as described by Tyler, Williams and Lewis (2006). Variability may be the result of intervention (Grunwell & Harding, 1996; Howard, 2004) or of maturing development (McLeod & Hewett, 2008) and for Tallulah both of these elements may hold true. A further factor to consider is the variability resulting from the transcription of Tallulah's speech. Although approximately ten percent of the sample was transcribed through consensus listening (see Chapter Three, Methods) the perceptual analysis particularly of her nasally realised segments, and often those in multi-word utterances, was sometimes challenging especially in terms of place of articulation. This is not to suggest that Tallulah's speech was not variable but that the transcription is "an abstraction" of speech data (Cucchiarini, 1996, p. 132) and "should never be considered the truth" (Muller, Damico, & Guendouzi, 2006, p. 11). This emphasises the need for sufficient data collection across different sampling types to allow the transcriber to look for significant patterns rather than singular speech events. For Tallulah variability was also evident with segments other than those that were nasally released but the same approach of needing several examples from different data sources held true.

The differences in speech output relating to speech sampling condition were primarily in the realisation of consonant clusters and multisyllabic words as described in section 4.26.2. However, the variability could not be described as systematic.

4.26.4 Does the psycholinguistic speech processing profile provide explanations of Tallulah's speech output patterns?

Tallulah's speech processing profile showed that input processing skills, assessed with a variety of tasks, were in the typical range for her age. By contrast, output skills were significantly impaired. As described in section 3.9.1., the stimuli used in the input activities were published items used for norm-referencing and were not based on Tallulah's own output errors; individually designed stimuli may have been more sensitive to processing difficulties. The production of accurate motor programmes, assumed to be "based on the child's stored representation" (Stackhouse & Wells, 1997, p. 82) was a clear area of difficulty. The profile does not offer an immediate explanation of the source of Tallulah's impaired speech output, other than her poor performance on the DDK task which indicated that she had difficulties with motor planning skills. However, Tallulah's non-word repetition was significantly better than her naming of matched real words. This suggested that motor programmes had not been updated but that her ability to produce more mature articulatory gestures was improving. It is possible that she had had difficulties with motor programming, impacting on the establishment and updating of motor programmes but her non-word repetition skills at T1 suggested that these were also resolving.

Given that the processing profile potentially offers an explanatory framework for specific aspects of speech output by supporting a summary of strengths and difficulties, the realisation of consonant clusters and multi-syllabic words were further considered.

One possible source of the vulnerability in the production of both of these aspects of output, consonant clusters (section 4.26.1.1.1) and multisyllabic words (section 4.26.2), was whether Tallulah's underlying phonological representations were weak or underspecified (James, 2009; Stackhouse & Wells, 1997). However, the profile of Tallulah's input processing skills at T1 suggested that this was not the case. Evidence of the relative strength of her underlying phonological representations may come from her production of unstressed syllables in a word initial position such as <u>GUI</u>TAR [ʔɪˈtʰ a̰ʔ] and PYJAMAS [əˈʤa˜məz̥] where the SIWI consonant was replaced with a glottal stop or deleted but the presence of the syllable was realised by an appropriate vowel. James et al. (2008) suggest that this indicates that the child has an awareness of the underlying phonological representation of the target word. For Tallulah therefore it appears that her realisations were more likely to reflect motor difficulties than input deficits as already discussed. However, it was interesting to see at T2 that although speech output had improved, Tallulah's phonological awareness skills (as assessed using Hatcher, 1994) did not show any real change, suggesting ongoing difficulties in tasks requiring segmentation and blending of words. Stackhouse (1992) discusses the "unfolding and changing nature" (p. 30) of speech difficulties. Tallulah's PSD could not unequivocally be attributed only to motor planning difficulties; it was more likely that she had multiple deficits, as suggested by other studies examining the processing skills of children with PSD (Pascoe et al., 2006; Wren et al., 2012). The framework does not offer any historical perspective on Tallulah's processing and it is not possible to tell if she had had input processing problems at an earlier stage in the development of her speech before the study began.

4.26.5 Does the intelligibility of Tallulah's speech vary across different speech elicitation conditions?

The quantitative scores for measures of Tallulah's speech output implied that her intelligibility would be compromised and this was strengthened by the phonological process analysis because of the negative impact of structural processes such as cluster reduction on word shapes (Faircloth & Faircloth, 1970). The most pervasive segmental difference in Tallulah's speech was the realisation of fricatives, primarily the alveolar segments /s/ and /z/, with nasal turbulence. Although it might not be unreasonable to assume that the impact on intelligibility would be similar to that of other segments that occur with similar frequency in words (Klein & Flint, 2006), the difference was a phonetic variation rather than one which reduced contrastiveness, such as, for example, stopping. In this respect nasal realisation of alveolar fricatives is similar to a lateral realisation of these targets. No information has been found in the literature about the possible impact on intelligibility of this type of frequently occurring but clearly delineated phonetic variance.

The intelligibility of Tallulah's speech, as measured through the perceptions of 66 adult listeners, showed that single words were least intelligible (mean, 54.82%), followed by conversational speech (mean 66.71%) and that imitated sentences were the most intelligible type of utterance (mean 80.30%). The differences between the sample types were significant. The difference between single words and conversational speech, in favour of the latter, mirrors the findings of other studies. For example, Speake et al.(2012) in a study of two ten-year-olds with PSD found that peer listeners identified MWU better than single words; Gordon-Brannan and Hodson (2000) found of a difference of about 10% in favour of conversational speech in study of intelligibility in pre-school children. However, in a study of five children with PSD, (Pascoe et al., 2006) only two of the children had this pattern. For Tallulah it is clear that structural and segmental errors had a significant impact on single word recognition; the mean score of 54.82% shows that only just over half of her single words were identified. However, the contextual and prosodic support available in conversational speech enabled listeners to perceive words more accurately and the success rate increased to two-thirds of her utterances being recognised (mean 66.71%).

It is interesting to note that Tallulah's imitated sentences were significantly more intelligible than either of the other two types of sample. Given the increased tendency to use open juncture in this task, it appears that listeners benefitted from the contextual support of a complete utterance together with Tallulah's "best speech" (Klintö et al., 2011). This allowed, for example, that consonant cluster realisation in the imitated sentences was similar to that in single words rather than conversational speech but the more accurate realisations benefitted from the contextual semantic and syntactic support of MWU.

One final important point is that although there were significant differences between the mean scores of the sample types, the range between the minimum and maximum words recognised was very wide for all types of words. The listeners' perceptions varied enormously; a few identified almost everything Tallulah said and a few recognised very little. A range of listener experience is commonly found in intelligibility studies with factors such as experience of disordered speech, familiarity of the speaker and variants such as age, sex and accent being suggested as influencing listeners' word recognition skills (Pennington & Miller, 2007). No such details were examined in relation to this current study.

4.26.6 Are any changes in Tallulah's speech output evident between two points in time and do any changes impact on the intelligibility of her speech?

The improvement in Tallulah's speech output between T1 and T2, a time span of 10 months, was demonstrated in the PCC measure of 91.47% at T2 (compared with 70.82% at T1) and score on the Picture Naming Test of whole word correct of 49/60 ($z = -1.32$) compared with 28/60 ($z = -5.53$) at T1. In single words her speech showed residual atypical patterns with minor immaturities and occasional nasal realisation of targets. This pattern was repeated in multi-word utterances where, for example, cluster reductions, as well as nasally realised segments, were still evident, although much less frequent than at T1. For example, THE TOY ELEPHANT WAS BROKEN realised as [ðə ˈtɔɪ ˈʔɛləfəñʔ wɒm̰ ˈbɹəʊkə˜n].

At T1, Tallulah's repetition of non-words matched to the real words elicited in the Picture Naming Test was overall in the range typical for a child of her age. The implication was that she was therefore managing the production of novel material more effectively than already known words. This might have reflected lack of lexical updating (Stackhouse & Wells, 1997) where the motor programmes of already known words were not changed to reflect the capacity to use more mature speech output skills. T1 assessment may have captured a point in her development towards this happening because by T2 real word naming was in the typical range. Tallulah's ability to produce novel material at T1, together with a pattern of variability that included the production of mature forms, could be interpreted as positive prognostic indicators. She had also been stimulable for all English phones, another important factor in prognosis (Glaspey & Stoel-Gammon, 2007; Powell & Miccio, 1996). Although in complex linguistic environments, Tallulah's emergent skills at T2 were vulnerable and utterances occasionally broke down, the frequency of variability which had been so evident at T1, had reduced.

Interestingly Tallulah still had difficulties with motor planning as evidenced by her performance on the DDK task which was essentially unchanged at T2. This suggests that she was learning to manage the phonetic and phonological demands of familiar words and phrases in spite of these ongoing motor deficits. DDK tasks, dissociated from meaning, do not draw upon established lexical representations. Therefore, if speech "emerges from the child's experience with the use of language across multiple levels of representation in many contexts" (Rvachew & Brosseau-Lapre, 2012, p. 284), in the absence of any gross neurological or structural abnormalities, DDK tasks are potentially no more indicative of actual speech performance than other oro-motor skills. However, poor performance on DDK tasks may be an important risk factor for persisting difficulties (Wren et al., 2012) and also a reflection of a highly impaired speech processing system (Pascoe et al., 2006).

Word juncture behaviours were similar at both points in time in the sentence imitation task and consideration of these data leads to a cautious conclusion that Tallulah's tendency to use open juncture was a response to the tasks and her awareness of being tested rather than necessarily a difficulty in managing word boundaries *per se*. By T2 her use of open juncture in conversational speech had decreased and with the improvements in her segmental system, at times short stretches of her speech output sounded perceptually entirely typical.

Changes in speech output resulted in significant improvements in intelligibility as judged by the listeners. This was evident across all types of sampling conditions and the relationships between them had changed so that words in conversational speech were now better recognised than those in imitated sentences; single words remained the least well identified data. The listeners' understanding of imitated sentences was actually worse at T2 (mean 74.79%) and the range between minimum and maximum scores remained very wide. It is interesting with a PCC of over 90% that the minimum scores across all sampling types were still so low (one listener recognised only 2 of the single words, another only just over 50% of the conversational speech). In a study of two children who had PSD, focussing on intervention for vowel difficulties, Speake et al. (2012) found that even when the children's vowel difficulties resolved, intelligibility, as judged by a group of peer listeners, showed a wide range of outcomes. It was suggested that there may be subtle qualitative difficulties remaining which impacted on the experience of the listeners and this may be the case for Tallulah. It may also be the case that some listeners are able to employ more effective strategies in dealing with speech that is difficult to understand but it is not at all clear what these may be.

4.27 Summary and conclusions

A comprehensive phonological process analysis (PPA) of Tallulah's speech at T1 identified that the main process used was cluster reduction; this was more evident in MWU than in SW. Further analysis beyond the scope of a typical PPA showed significant segmental difficulties in the form of atypical nasal realisations of alveolar fricatives; these were pervasive in all types of elicitation conditions. Analysis of MWU revealed segmental and prosodic features which were not evident from a traditional single word naming test, including more frequent use of open juncture than might be predicted from the literature. In addition, Tallulah's speech was highly variable and not all variability was between her atypical patterns and a more mature adult target which would be indicative of progress, although this did occur.

Psycholinguistic assessment demonstrated that Tallulah's speech processing skills were stronger in input tasks than in output activities, and her speech was more accurate in non-word repetition than in picture naming. However, Tallulah's performance on a DDK task indicated that she had difficulties in motor planning. One explanatory interpretation of the psycholinguistic profile is that difficulties in motor planning had affected the development of Tallulah's motor programmes. However, as she had matured and speech processing skills had further developed Tallulah was better able to realise mature speech patterns, as demonstrated by her non-word repetition at this point in time. These more mature speech patterns were also seen with the examples of progressive variability. However, at T1 she had not updated existing motor programmes, as demonstrated by her real word naming.

Tallulah's severe and persisting speech difficulties affected the intelligibility of her speech in all types of utterance although listeners were better able to recognise words in MWU than as single items. Listener identification of all types of utterance showed a wide range of outcomes.

By T2, Tallulah's speech output and her intelligibility had both significantly improved although she continued to show residual difficulties reflecting those identified at T1.

The next case study in Chapter Five is Harry, who was 7;5 at the time of the first assessment.

Chapter Five

Case Study: Harry [2]

5.1 Background

At the beginning of the study Harry was 7;5; he was first referred for speech and language therapy when he was 3;1 because according to the health visitor he had "poor speech development" and it gradually became evident that he had severe difficulties with speech output. There was no family history of delays in speech, language or literacy development apart from a note in the file that a cousin had speech and language therapy; no other details were recorded. No concerns had been reported about Harry's hearing. From 4;1 until 5;3 he attended an Early Years' education facility where he had small group specialist teaching and intensive speech and language therapy. Intervention continued on a less intensive basis when he started mainstream school; at the age of 5;5 the speech and language therapist commented that Harry's "connected speech is mainly unintelligible unless in context". He was reported by his class teacher at 7;5 to have severely delayed literacy skills.

5.2 Initial observations T1 (C.A. 7;5)

The first impression of Harry was that he was talkative, usually speaking in a loud voice. His voice quality was slightly hoarse and there was tension around his mouth and jaw, resulting at times in a "tense voice quality"(Laver, 1980, p. 146-156). He expressed his opinions and engaged in conversation enthusiastically but was less keen to demonstrate recent therapy activities, although did so with a little encouragement. A recent language assessment had indicated age appropriate language skills in both receptive and expressive tests (see appendix 5.1). He was able hold a conversation with ease, in spite of his many atypical segmental realisations and, particularly in extended talk, his sometimes poor intelligibility. He used contextual and prosodic information well and would repeat or rephrase something if asked what he had said, but he was not observed to change the way a particular word was said to improve clarity without a prompt. Harry's speech production at this preliminary examination was characterised by cluster reduction, atypical voicing, difficulty with multisyllabic words and stretches of conversation that were difficult to understand.

[2] Material from this chapter appeared in Speake et al., 2011

Harry expressed clear views about his speech difficulties; he said that he was "fed-up" when people did not understand him ("it's boring") and that this happened "lots of times every day, a thousand times a day".

5.3 Initial assessment T1

Harry's input processing skills and speech output skills in single words and multi-word utterances were assessed following the approach described in Chapter Three, Methods (see appendix 5.2 for his speech processing profile and 5.3 for the mapping of this profile to the speech processing model).

5.4 Input processing skills T1

The investigation of Harry's input processing skills included assessment tasks from Stackhouse, Vance, Pascoe and Wells (2007) and other non-standardised activities.

- Discrimination between same/different SFWF single features and s-cluster sequences in real words and non-words for example, lo<u>t</u>/lo<u>ss</u>; vo<u>t</u>/vo<u>s</u>; lo<u>ts</u>/lo<u>st</u>; vo<u>ts</u>/vo<u>st</u>, (Stackhouse et al., 2007). Harry's overall number correct was 33/36 compared with a mean score of 35.25/36 (S.D. 0.79) for a typical 7-year-old. His z-score was -2.84, indicating a significant level of difficulty. However, there was a difference between real words 18/18, z=0.46, in the typical range for his age and a score of 15/18, z=-5.2 for non-words, which was considerably below the range expected for a child of his age.

- Discrimination of segmental differences between pairs of complex non-words (for example, /spəʊb/ vs. /spəʊd/; /ʧʌsp/ vs. /ʧʌps/, (Stackhouse et al., 2007). Harry's overall score was 67.5% compared with a score of 90.66% (S.D. 7.5%) for a typical 7-year-old. His z score was -3.08 indicating a significant level of difficulty. His ability to judge that a pair of non-words was the same resulted in a z score of -2.38; his ability to judge that a pair of words was different was at a similar level, z=-2.74. The majority of errors occurred with stimuli reflecting differences in place of articulation with 5 errors in 11 items, for example, /ˈbɑgli/ vs. /ˈbɑdli/, and metathesis with 3 errors in 6 items, for example, /ˈbɪkət/ vs. /ˈbɪtək/. With cluster sequences 3/4 were correct, /ʧʌps/ vs. /ʧʌsp/ was the error, and 1/2 vowel judgements were correct with /krɪb/ and /krɛb/ being judged the same.

- Auditory lexical decision (ALD) with pictures (Stackhouse et al., 2007), recognising production errors in 1, 2 and 3/4 syllable words. Harry's scores were typical for his age with an overall score of 113/120 compared with a mean for typically developing children of 114.7, (S.D. 3.17), z=-0.53. His score for 1 syllable words was 38/40, z=-0.12, for 2 syllable words 39/40, z=0.17, and for 3/4 syllable words 36/40, z=-1.08. Errors with 3/4 syllable words included acceptance of [ˈwəʊndəbaʊt] for ROUNDABOUT; [ˈpærəsut] for PARACHUTE; [ˈbʌtəfaɪ] for BUTTERFLY. These mispronunciations are all productions which Harry used in his own speech. Three of the four errors related to place of articulation and one to cluster reduction.

- Auditory lexical discrimination (ALD) without pictures (Stackhouse et al., 2007). Harry was asked to judge whether the multisyllabic items that he heard were real words or non-words, for example, /ˈɛfɪlənt/ vs. elephant. Seven-year-olds are expected to be 98-100% correct and test scores generally reach ceiling at age 6 years. Harry scored 93.33% (28/30). He made no errors in judging real words; he made one perseveration error (judging /ˈhɒspɪpl̩/ as a real word) and one error in detecting metathesis (judging /ˈɛfɪlənt/ to be real word).

- Auditory lexical decision, judging words in sentences, for example: mouse/mouth, "point to the boy's *mouse* was full of food" (Stackhouse et al., 2007). No norms are available for Harry's age group; typically developing 5-year-olds are expected to score almost at ceiling. The overall percentage correct for Harry's responses was 84.72%; he was largely successful with CVC words apart from the minimal pair MOUSE/MOUTH, where he made 8 errors in 36 items. In his own speech he used /s/ or /z/ for /f/ and /v/ as in [faɪz̥] for 'five' and it may be that fricatives in this SFWF position presented him with difficulties in both perception and production. For words that contained word initial consonant clusters (CLOWN/CROWN and GRASS/GLASS), when asked to complete a preliminary identification at single word level, Harry made no errors but at sentence level he made 8 errors in 36 items for CLOWN/CROWN and 21 errors in 36 items for GRASS/GLASS. As with SFWF fricatives, these errors appeared to indicate a link between Harry's speech perception and production skills, because cluster reduction was also evident in his speech.

Harry's phonological awareness skills were assessed using the assessment from the Sound Linkage Training Programme (Hatcher, 1994) (note, these tasks typically tapped both input and output skills). These activities assess phonological processing skills associated with the representation and manipulation of sounds in words. Harry scored 18/36; the test does not give details of norms but is presented as suitable for children at the early stages of literacy development. Harry was able to listen to a word segmented into syllables (for example, "win-dow") and say what the word was (6/6). He could also listen to segmented phonemes (for example, r-ai-n) and blend them into words (5/6). His scores on these tasks indicated that phonological representations for these tested words were accurate. Given a choice of three words Harry could verbally identify which two rhymed with some success (4/6 items correct) but he was not confident in the task. He was able to segment words into separate phonemes at CVC level but not when words contained consonant clusters (2/6 correct). He was not able to complete a phoneme deletion task, (for example "take 's' away from 'stop'") (0/6) or carry out a phoneme transposition task ("net" is reversed to become "ten") (1/6) with any reliability. Harry's responses to these phonological awareness activities suggested that he had some awareness of the internal structure of phonological representations but was reliant on adult modelling and support to manipulate phonological information beyond a basic level. This need for adult support in the form of repetition and a slow rate of stimuli presentation to introduce the activity was evident in another non-standardised task to assess identification of onset and coda segments. Harry was independently able to silently sort pictures of CVC words by onset but not coda, which again highlighted a difficulty with identification of word-final speech sounds.

Harry's performance on these assessments indicated that his ability to recognise mispronunciations by an adult even with multi-syllabic words was typical for a child of his age, and he was able to recognise similarities and differences in pairs of real words. However, beyond a CVC level he found it difficult to manipulate phonemes in segmentation and blending tasks, and even with CVC words was not able to reliably identify coda segments. At sentence level he showed difficulties in discrimination of real words where the difference was between fricatives in SFWF position and with SIWI velar plus approximant consonant clusters. These two patterns reflected difficulties in Harry's output in that both were patterns that he did not realise consistently in his own speech.

Phonological awareness skills were at an early stage of development with Harry's ability to manipulate sounds within words at a level below onset and rhyme still limited. His input difficulties with complex non-words might have implications for lexical development because his impaired ability to discriminate speech sounds in novel words would impact on the development of accurate phonological representations and associated motor programmes. This could also have implications for the updating of already established motor programmes in that lexical development and phonological development are closely linked (Stoel-Gammon, 2011).

5.5 Speech output skills T1

Harry's speech output skills were assessed using a range of single word tests; the Picture Naming Task (Stackhouse et al., 2007) and the Non-Word Repetition Task (Stackhouse et al., 2007). He also completed subtests of the DEAP (Dodd et al., 2002). The single word (SW) analysis was based on 110 items collected during these tasks (appendix 5.4). The multi-word data are from the analysis of T1 conversational speech (CS) samples 1-7 (appendices 5.5 to 5.10) and selected imitated sentences from the Connected Speech Processes (CSP) Repetition Task (Stackhouse et al., 2007), (appendix 5.11 and table 5.20); there are occasional examples from other conversational speech, which are indicated in the text.

The Picture Naming Task (Stackhouse et al., 2007) allowed comparison of Harry's whole word production with the expected score for a child of his age (see table 5.1); scoring is based on the number of whole words that match the adult target. His overall score across all word lengths was 21/60 (35.00%), z=-8.44, compared with the mean score for 7-year-olds of 54.2/60 (90.33%), S.D. 3.93. Harry's score indicated a severe level of difficulty in comparison with a typically developing peer group. His scores for 1 syllable (9/20, z=-8.16), 2 syllable (8/20, z=-8.16), and for 3/4 syllable words (4/20, z=-5.55) indicated a severe level of difficulty across all word lengths.

Harry completed the Non-Word Repetition Task (Stackhouse et al., 2007), (see table 5.1). His score across all word lengths was 25/60 (41.66%), z=-5.11, compared with an expected mean score of 48.85/60 (81.41%), S.D. 4.66 for typical 7-year-olds, indicating a severe level of difficulty. Harry scored equally poorly across all word lengths as shown by scores for 1 (z=-3.75), 2 (z=-4.71) and 3/4 (z=-3.34) syllable words respectively.

Table 5.1 Harry: Scores Picture Naming Task and Non-Word Repetition Task T1

	Picture Naming Task (real words)		Non-word Repetition Task	
Word structure	Norms age 7 years (mean, S.D.)	Harry's score (z-score)	Norms age 7 years (mean, S.D.)	Harry's score (z-score)
1 syllable (N=20)	18.8 (1.20)	9 (-8.16)	16.05 (1.88)	9 (-3.75)
2 syllable (N=20)	18.45 (1.28)	8 (-8.16)	16.95 (1.90)	8 (-4.71)
3 & 4 syllable words (N=20)	16.95 (2.33)	4 (-5.55)	15.80 (2.33)	8 (-3.34)
Total (N=60)	54.2 (3.93)	21 (-8.44)	48.85 (4.66)	25 (-5.11)

Scores on both real word naming and on non-word repetition indicated severe levels of difficulty when compared with the scores achieved by typical children. Item-by-item analysis revealed segmental realisations that were closely matched across the two different types of stimuli. For example, BRUSH realised as [bwʌs] and the non-word /bɹɪʃ/ realised as [bwɪs]; AEROPLANE realised as [ˈɛləpeɪn] and /ˈɒɹəpləʊn/ realised as [ˈɒləpəʊn]. There were differences, for example, FISHING was realised as [ˈfɪsɪn] and /ˈfɒʃɪŋ/ as [ˈfɒsɪŋ], with the SFWF nasal velar matching the adult target. However, these differences were not always in favour of non-word accuracy, so for example, SNAKE was realised accurately but the matched non-word /snaɪk/ was realised as [snaɪt], with fronting of the SFWF velar plosive.

The similarity between the realisations of items in the naming task and non-word repetition tasks suggested that similar motor and perceptual constraints affected Harry's output of both previously known and novel words. Differences between output levels, for example, identified difficulties with word production in naming tasks and better performance with real word and non-word repetition might be indicative of specific processing problems with motor programmes (Stackhouse & Wells, 1997). However, Harry showed no such differential in levels of output and his scores were interpreted as symptomatic of diffuse deficits across his speech processing system.

Non-published output-based phonological awareness tasks showed that Harry could accurately segment words into syllables by tapping or clapping but was not able to segment CVC words reliably into separate phonemes. He was reliant on adult scaffolding to manipulate segments in simple words, requiring repetition of stimuli and slow rates of presentation. He benefitted from having physical apparatus such a blocks or counters to support his performance on phonological tasks. He was able to blend C-V-C elements to produce whole CVC words but not able to do this at CCVC level because he had difficulty with consonant cluster production. For example, when asked to blend /s-t-ɛ-p/ he produced [sɛp]. His ability to generate rhymes based on common CVC words was limited to a few high frequency examples such as "words that rhyme with cat", where he was able to think of bat, mat and hat but was unable to generate any rhymes for "man" or "hot". This was assumed to be linked to Harry having learned through repeated exposure to, for example, "at" rhymes in classroom activities, something which he himself commented on. His reliance on adult support in phonological awareness tasks was partly due to processing load; he was unable to manipulate segments within a word and still reliably recall the task he had been asked to do. He was also poor at sounding out words, and therefore almost certainly in using sub-vocal rehearsal, which affected both segmentation and blending skills.

5.6 Oro-motor assessment and diadochokinesis (DDK) T1

Harry's oro-motor skills were assessed using items from the DEAP (Dodd et al., 2002). Harry's non-speech movements in isolation (for example, tongue elevation; lip spreading; lip rounding) and in sequences (for example, a cough followed by a kiss gesture) were accurate for movements that did not involve his tongue. He was not able to elevate his tongue to verbal command or in copying an adult model; lateral movements i.e. moving the tongue from one corner of the mouth and back again several times lacked precision in that he moved the tongue body and did not place his tongue tip exactly in the corners of his mouth. His movements were also rather slow and deliberate. Harry's performance suggested that he had oro-motor difficulties. Williams and Stackhouse (2000) found that 70% of typical 5-year-olds were unable to elevate their tongue tip in an oro-motor task, and it may be that Harry's difficulties were a reflection of an immature motor system.

Harry's DDK skills were assessed for rate and accuracy in a non-standardised way through repetition of single segments [p], [t], [k] (see Methods, Chapter Three). He was asked to do this 10 times after being given an adult model and three practise attempts. Harry was able to produce all three segments in isolation and repeat them, for example, [p], [p], [p]. However, he was unable to produce the sequence [p], [t], [k] with articulatory ease in that his attempts lacked fluency, with frequent pauses and hesitations between segments. He did not manage to produce any accurate sequences. For example: trial 1 [p, k, t]; 2 [p, t, t]; 3 [p, k, k]; 4 [p, k, k]; 5 [p, k, t].

Harry's inaccurate and inconsistent performance on DDK sequences was suggestive of difficulties with motor planning. However, his lack of speed and poor precision might also indicate that he had some degree of motor execution difficulties, although within the limitations of this task (and possibly more generally) it may be difficult to isolate the relative impact of difficulties with motor planning and execution.

5.7 Phonetic inventory T1

Harry's phonetic inventory for consonants, based on single word and utterance level analysis, is listed in table 5.2.

Table 5.2 Harry: Phonetic inventory (consonants) in SW and MWU T1

	Bilabial	Labiodental	Dental	Alveolar	Palatal	Velar	Glottal
Plosive	p b			t d		k g	ʔ
Ejective	p'			t'		k'	
Nasal	m			n		ŋ	
Fricative		f v	ð	s z			h
Approximant	w			l	j		

Harry's vowel inventory included all vowels expected in his accent of English (see Chapter Three, Methods). In this analysis the realisation of /t/ as a glottal stop in SFWW and SFWF positions and the vocalisation of SFWF /l/ to [ʊ] (Grunwell, 1987) were judged as typical for Harry's accent of English.

5.8 Stimulability T1

Harry was not stimulable for any of the phones not in his inventory, even with maximal modelling i.e. attending to auditory and visual information and given appropriate cues such as "round your lips" to facilitate the production of /ʃ/.

5.9 PCC T1

Harry's SW PCC was 62.11% and his PVC was 95.83%, giving a PPC of 78.97%. Scores were derived from 110 single words. This PCC puts Harry's speech into the Shriberg & Kwiatkowski, (1982) category of moderate to severe difficulties for consonant production (range: 50-64%).

5.10 Phonological process analysis T1

A phonological process analysis was completed using data primarily from single words and conversational speech, supplemented by data from imitated sentences where appropriate. There was evidence both in SW and MWU of structural and systemic processes (see table 5.3). The main structural process in evidence was cluster reduction. Systemic processes included velar fronting, deaffrication, gliding and voicing; Harry also atypically realised SIWW and SFWF labiodental fricatives as alveolar fricatives. There was some evidence of variability in his speech.

Table 5.3 Harry: Phonological processes (consonants) T1

	Target (SW)	**Harry's realisation**	**Target (conversational speech CS)**	**Harry's realisation**
Structural processes				
Cluster reduction	GLOVES: epenthesis AEROPLANE: CR	[gəˈlʌps] [ˈɛələpeɪ˜n]	IT SLOWLY STARTS TO MELT (CS 1)	[ɪʔ ˈsəʊwi ˈsɑts tʰ ə ˈmɛʊʔ]
Systemic processes				
Velar fronting	KANGAROO	[ˈtʰ æ˜ndəwu]	SHE MUST BE COOKING ALL THE TIME (conv.)	[ˈtʰ ʊʔɪ˜n ɔl ə ˈtʰ aɪ˜m]
Voicing (complete devoicing of SFWF segments)	LEGS	[lɛks]	MUMMY IS (CS 6)	[ˈmʌ˜mɪ̆ ˈɪs]
Deaffrication	JELLY	[ˈd̜ɛli]	IT(S) JUST ABOUT (CS 1)	[ɪʔ ˈdʌst əˈbaʊʔ]
Gliding	RING	[wɪ˜ŋ]	TRICK OR TREAT (CS 5)	[ˈtwɪʔ ɔ ˈtwit]
Alveolar realisation of labiodental fricatives (SIWW & SFWF)	FIVE	[faɪz̜]	THEY FALL OVER (CS 1)	[di ˈfəʊ ˈʔəʊzə]

5.10.1 Structural processes T1

As previously mentioned, the main structural process in Harry's speech was cluster reduction although there were also occasional instances in MWU of the deletion of final consonants as in BIG WAVE CAME realised as [bɪʔ ˈweɪ ˈkʰ ɛ˜ːm] (CS 4) and weak syllables as in HEART ATTACK realised as [ˈhɑʔ ˈtʰ æk] (CS 3).

5.10.1.1 SIWI and SIWW clusters in single words

All consonant clusters were examined (see table 5.4); in SW there were 25 examples of SIWI clusters and 8 SIWW; 23 were plosive/fricative plus approximant or /r/ clusters and 10 were /s/ clusters. There were a few examples of lexical effects so that, SNAKE and SPIDER were always produced accurately; recent intervention had targeted these words, so Harry had frequently been asked to say them, which may have positively influenced his production.

Table 5.4 Harry: Realisation of syllable initial word initial (SIWI) and syllable initial within word (SIWW) consonant clusters in single words and conversational speech T1

Process	Single words (SW) (33 items)	Conversational speech (CS) (26 items)	Examples
None (i.e. cluster realised accurately)	30.35% (10/33)	30.76% (8/26); (note: 5 were correct realisation of /sp/ in SPIDER	PLATE [pleɪt] (SW); FLOWER [ˈflaʊwə] (SW); SLIDE [slaɪd] (CS 1)
Realised with 2 elements (but one or both elements have immature or atypical realisation)	33.33% (11/33)	19.23% (5/26) plus 3.8% (1/26) triple /s/ cluster realised with 2 elements	BREAD [ˈbwɛt'] (SW); UMBRELLA [ʌ˜mbəˈwɛlə] (SW); GROUP [gwup'] (CS 5); CRUST [twʌs] (CS 2); HAIRDRESSER [hɛəˈdwɛsə] (SW); BRIDGE [bwɪts] (SW)
Reduced to a single element	30.35% (10/33)	42.3% (11/26)	BUTTERFLY [ˈbʌtə˘faɪ] (SW); CRUST [tʰ ʌst] (CS 2); STARTS [sɑts] (CS 1); AEROPLANE [ˈɛələpeɪ˜n] (SW); STRAWBERRY [ˈsɔbɛːɪ] (SW)
Coalescence	6.06% (2/33)	3.8% (1/26)	SWING [sfɪ˜nh] (SW); SQUARE [fɛə] (SW); SWEETIES [ˈsfiʔis] (CS 5)

There were also three examples of epenthesis in the SW data, two with adult targets of voiced velar plosive plus approximant: GRASS realised as [gəwɑs]; GLOVES realised as [gəlʌps] and one with the voiced bilabial plosive plus approximant UMBRELLA realised as [ʌ˜mbəˈwɛlə].

5.10.1.2 SIWI and SIWW clusters in conversational speech

There were 26 unambiguous examples of SIWI consonant clusters in the conversational speech samples, i.e. where the word was intelligible and the target known, and no SIWW examples; 13 clusters were plosive/fricative plus approximant or /r/ clusters and 13 were /s/ clusters (see table 5.4).

The number of cluster realisations that matched the adult targets in SW and conversational speech was very similar, i.e. around thirty percent although 19.23% of the CS score is accounted for in five realisations of /sp/ in <u>SP</u>IDER and an adjustment for this (i.e. only counting that word once) would suggest greater accuracy in SW. Gliding of the second element of /r/ clusters was a major factor in both SW and MWU, for example, <u>TR</u>ICK OR <u>TR</u>EAT (CS 5) was realised as [ˈtwɪʔ ɔ ˈtwɪt] and there were 3 examples of epenthesis in SW but none in conversational speech; few of the words occurred in both conditions so it was not possible to do a direct comparison of their realisation in SW and conversational speech.

Reduction of the cluster to a single element was more frequent in MWU than in SW (42.3% compared with 33.33%), for example, IT <u>SL</u>OWLY <u>ST</u>ARTS TO MELT (CS 1) was realised as [ɪʔ ˈsəʊwi ˈsɑts tʰ ə ˈmɛʊʔ]. /l/ clusters were always reduced to a single element in conversational speech (6/6 examples) compared with 2/7 examples in SW (3 were realised accurately, 1 with epenthesis and 1 with a glide). These data also suggest that Harry was using clusters with greater accuracy in SW than in MWU. The one exception to this is /s/ clusters where (counting only one production of SPIDER) Harry realised 66.66% (6/9) of targets in conversational speech but only 36.36% (4/11) in SW. This might be explained by the words used for the data collection of cluster types. The SW sample elicited a wider range of /s/ clusters (9 different clusters, including 3 three-element clusters) than Harry produced in conversational speech (5 different clusters).

5.10.1.3 SFWW and SFWF consonant clusters

SFWF clusters were also examined (see table 5.5). In SW there were 6 examples of SFWF or SFWW consonant clusters; 3 were realised accurately and 3 were not. In conversational speech 23 SFWF clusters were conservatively identified and almost 80% were realised accurately, encompassing a range of different types of clusters.

Table 5.5 Harry: Realisation of SFWF and SFWW consonant clusters in SW and CS T1

Process	Single words (SW) (6 items)	Conversational speech (CS) (23 items)	Examples
None (i.e. cluster realised accurately)	50% (3/6)	78.26% (18/23)	ELEPHA<u>NT</u> [ˈɛləfə˜nt'] (SW); JU<u>MP</u> [dʌ˜mp] (SW); ROU<u>ND</u>ABOUT [waʊ˜nd̥əbaʊt'] (SW); JU<u>ST</u> [dʌst] (CS 1); BO<u>X</u> [bɒks] (CS 5); CO<u>MED</u> [ˈkʰ ʌ˜md̥'] (CS 4)
Reduction to a single element		17.39% (4/23)	CRU<u>ST</u> [ˈtwʌs] (CS 2); BREAKFA<u>ST</u> [ˈbɛʔkəs] (CS 5)
FCD		4.34% (1/23)	LA<u>ND</u> [le˜ɪ] (CS 4)
Voicing (i.e. SFWF voiced segments realised in a devoiced form)	16.66% (1/6)		LE<u>GS</u> [lɛks] (SW);
Deaffrication (and CR)	33.33% (2/6)		ORA<u>NGE</u> [ˈɒwɪs] (SW); SPO<u>NGE</u> [spʌ˜ns], (SW)

5.10.2 Systemic processes T1

The most frequently occurring systemic processes were velar fronting, devoicing of SFWF obstruents; deaffrication; gliding and alveolar realisation of labiodental fricatives in SFWF and SIWW positions (for example, OVER realised as [ˈʔəʊzə]; see table 5.3).

5.10.2.1 Velar Fronting

Harry's realisation of velar plosives was varied in terms of placement and voicing.

- In SW 75% (6/8) of word initial velars were realised as velars with appropriate voicing; 25% (2/8) were fronted. In CS 64.7% (11/17) were realised as velars and 35.29% (6/17) were fronted. Variability in production was evident, for example, in CS 4 GOOSE was realised with a SIWI velar on 3/4 occasions and fronted on 1/4; CAME showed the same pattern.

- In SW the SFWF target was always realised as a velar (9/9) but the voiced segment /ɡ/ was realised as the voiceless cognate, for example, FROG as [fɒk']. In conversational speech 54.54% (6/11) of SFWF targets were realised as velars but, particularly within an utterance, Harry realised segments as glottal stops, for example, BIG GROUP [bɪʔ ˈgwup']. SFWF plosives were frequently realised as ejectives in SW (57.14%); this also occurred in conversational speech in utterance final positions, for example, ALL THE WAY BACK [ˈɔlə ˈweɪ ˈbæk'].

- Within-word velar targets were generally realised as velars (5/6) but there was a tendency (2/6) to voice voiceless segments, for example, MONKEY was realised as [ˈmʌŋgi]; this also appeared within utterances across word boundaries where, for example, PECK IT was realised as [pɛg ɪt̚] and, in another conversation, NICK IT as [nɪg ɪt].

In summary, velar placement was generally more accurate in SW but subject to variability in MWU, where fronting occurred more frequently. SFWF devoicing of velar targets was evident in SW as were ejective realisations; these also occurred in utterance final positions and it might be predicted that devoicing of voiced segments would also occur in this position although there were no examples within these data. Within words and across word boundaries in MWU, voiceless velars were liable to be voiced although in MWU glottal stops also occurred; this was not evident in SW.

5.10.2.2. Voicing

The voicing processes described with velars applied to other plosives and fricatives and were evident in both SW and MWU (see table 5.6); these were principally complete devoicing of SFWF segments (partial devoicing occurs in typical speech, "voicing may end early", Ball & Mu¨ller, 2005, p. 194). There were also examples of the harmonisation of voicing of within-word or across word boundary phones.

Table 5.6 Harry: Examples of voicing processes T1

Voicing process	Examples
Devoicing of SFWF segments	FIVE [faɪz̥] (SW); PIG [bɪk] (SW); 'COS [tʰ əs] (CS 2); VILLAGE [ˈbɪlɪs] (CS 5); HAD [hæt'] (CS 5)
Voicing within word or across word boundary	BISCUIT [ˈbɪʔgɪt'] (SW); RIP IT [ˈwɪb ɪʔ] (conv.)

The devoicing of word final obstruents was perceptually quite disruptive because vowel duration shortened ahead of the unvoiced segment. This impacted on the intelligibility of

Harry's speech especially when single syllable information carrying words were affected. If this devoiced element combined with another segmental process such as cluster reduction or velar fronting, it could make the intended target unclear. For example, CRAB realised as [t̬wæp']; BREAD realised as [ˈbwɛt']; FROG realised as [fɒk'].

5.10.2.3 Deaffrication

Harry always realised the post alveolar affricates /ʧ/ and /ʤ/ as immature forms, either as a stop or an affricate without the post-alveolar placement. In both SW and MWU SIWI targets were realised as [t] and [d] and SFWF were [ts] and [dz] or [s] and [z]. For example, CHAIR was realised as [tʰ ɛə] and BRIDGE as [bwɪts]. (Note: the use of the term deaffrication strictly speaking denotes loss of the fricative element as in JUMP realised as [dʌ˜mp]. Its use in this section is broader to cover all changes to the realisation of affricate segments).

5.10.2.4 Gliding

Harry consistently glided /r/ to [w] and he was not stimulable for /r/. /l/ was realised correctly apart from in contexts that were liable to omission i.e. multisyllabic words, for example HELICOPTER was realised as [ˈhɛɪkʰ ɒʔtə].

5.10.2.5 Labiodental fricatives

Harry frequently realised labiodental fricatives as alveolar fricatives in SFWF or SIWW positions; for example, O<u>F</u> in the utterance I LIKE THE CRUST OF THE BREAD (CS 2) [ʔaɪ ˈlaɪʔ ðə ˈt̬ʌ_st ɒz͡. ə ˈb̬wɛt]. This process is not developmentally typical. In SW this occurred in 57.14% (4/7) possible words, including examples where the target / θ /, with a predicted realisation of the immature labiodental [f], was realised instead as /s/ as in TEETH [tʰ is]. In another example, the target KNIFE was realised as [naɪf] but the plural form as [ˈnaɪsɪs]. In the conversational speech data there were several examples of this atypical process, for example, HARD AND TOUGH (CS 2) [ˈhɑd ən ˈtʌs]; there was just one where /v/ was realised as a typical voiced labiodental fricative in OVER [ˈəʊvə], previously in the same utterance it was realised as [ˈəʊzə]. Harry was easily stimulable for labiodental fricatives in SFWF and SIWW positions.

5.10.3 Summary of phonological process analysis T1

The most frequent and potentially most significant phonological process found in Harry's speech and one which might impact on intelligibility was cluster reduction and simplification (Hodson & Paden, 1981; Weston & Shriberg, 1992; Yavas & Lamprecht, 1988). In addition, multiple systemic processes might also impact on intelligibility because of the cumulative effects on the segmental integrity of individual words. However, this phonological process analysis had not captured all the data which might be important in providing a full description of Harry's individual speech patterns.

5.11 Features not captured through phonological process analysis T1

The phonological process analysis revealed a wealth of information which contributed to the description and explanation of Harry's speech patterns and intelligibility. However, in the course of the assessment it became apparent that there were other features which could not be accounted for through a traditional phonological process analysis. These particular features were lexical idiosyncrasies and his variability in speech output, and word juncture behaviours in multi-word utterances.

5.11.1 Lexical "idiosyncrasies"

In addition to features already described, Harry's speech also showed differences that might be characterised as lexical idiosyncrasies (see table 5.7). These may be so called "frozen" forms (Bryan & Howard, 1992) in that they were lexically specific and consistently realised. They also tended to be associated with production of particular multisyllabic words. This description of "frozen" forms is applied to lexical items where motor programmes established at an earlier time in development are not updated as the child's phonological and phonetic skills mature (Stackhouse & Wells, 1997), possibly due to difficulties with motor programming. Thus, their realisation may appear to be very immature or sometimes present with segmental patterns that are not obviously compatible with other output in the child's system.

Table 5.7 Harry: Examples of lexical idiosyncrasies T1

Word	Typical realisation	Harry's realisation
MEDIUM	/ˈmĭdijə˜m/	[ˈmĭdəmə˜n] (conv.)
SUPPOSED	/səˈpəʊzd/	[smə˜ʊs] (conv.)
FUNERAL	/ˈfjunəɹəl/	[ˈfunəbəl] (CS 3)
PYJAMAS	/pʰ əˈʤɑ˜məz/	[wiˈdɑ˜mɪs] (SW)

The fact that these differences in word realisation are not always obviously process based reduced their predictability and for Harry these now chronologically mismatched items might, depending on context, negatively impact on intelligibility.

5.11.2 Variability

In contrast with "frozen" forms, there were numerous examples of variability in Harry's SW assessment (see table 5.8), with multisyllabic words often showing at least one segmental difference when elicited at different times. These variations might be interpreted as Harry attempting to modify his speech towards the achievement of realisations that were closer to the adult model which could be termed progressive variability (and some versions were indeed more phonologically mature than others), (see Chapter Four, Tallulah, section 4.11.3). However, with the possible exception of consonant clusters (see section 5.26.1.1.1) this was not usually the case and the productions were not consecutively realised with greater accuracy. He rarely, if ever, changed his realisations in this way except in response to a direct adult request.

Another interpretation of Harry's output variations may be that they were due to difficulties in motor planning and/or phonological assembly. The differentiation between these two terms is unclear. Motor planning has been defined as "where the motor programs of individual words are assembled into a single utterance plan" (Stackhouse & Wells, 1997, p. 165). Phonological assembly has been described as the process of "selecting and sequencing phonemes (i.e. assembling a phonological template for the utterance)" (Dodd, Holm, Crosbie, & McCormack, 2005, p. 58). One difference between the terms is that Stackhouse and Wells (1997) never refer to phonemes as elements of speech processing. The DEAP Inconsistency Assessment (Dodd et al., 2002), might be one way of conceptualising these observations. However, in spite of his variable productions Harry did not reach criterion of 40% variability for a diagnosis of inconsistent speech disorder. Of note, there were also occasional naming errors which may have had a semantic basis, for example, "madearound" for ROUNDABOUT.

Table 5.8 Harry: Variability in realisation of single words T1

Target (typical adult realisation)	**Harry's realisations**
KANGAROO /ˈkaŋgəɹu/	[ˈtʰ æ̃ndwu]; [ˈkʰæ̃ŋgəwu]; [ˈkʰæ̃ndəwu];

	[ˈtʰ æŋgəwu]
GLOVES /glʌvz/	[dɒps]; [gəˈlʌps]
TEETH /tiθ/	[tʰis]; [dif̺]
FIVE /faɪv/	[faɪ˷z̥]; [faɪ̤v]; [faɪv̥]; [faɪv]

This variability was also evident in MWU where, as already described in the discussion about velar fronting, Harry's realisation of a particular word might be different, even within a single utterance. This can be seen in the following example from conversational speech with the words TIGER and LEOPARDS:

> <u>TIGER-</u>AND KNOW WHAT? <u>TUH-</u>NOTHING EATS <u>TIGERS</u> DO THEY? EVEN <u>LEOPARDS</u> CAN'T 'COS <u>LEH-</u> 'COS <u>TIGERS</u> EAT <u>LEOPARDS</u>
>
> [ˈtʰ aɪɣə (.) æ̃n ˈnə̃ʊ wɒʔ ˈtʰ ʌh (.) nʌ̃sɪ̃n ˈʔits̪ ˈtʰ aɪgəs du ðeɪ (.) ˈʔijə̃n ˈlɛʔbəs ˈtʰ ɑ̃nʔ tʰ əs ˈlɛb̹ (.) tʰ əs ˈtʰ aɪg̟əs ˈiʔ ˈlɛʔbəts]

In the first production of TIGERS the SIWW velar is realised as a velar fricative; in LEOPARD processes of segment deletion and SFWF cluster reduction operate variably across the two different tokens of the word.

Further evidence of variability emerged when comparing productions of SW and the utterance level productions from the imitated sentences of the CSP task. For example, Harry's realisation of the target ELEPHANT in I GAVE THE ELEPHANT A BANANA [aɪ ˈgeɪ̆s ə̃n bə(.)ˈnɛ̃ləbə̃nʔjəʔ ə (.) bə̃ˈnɑ̃nə], was contrasted with his SW realisation [ˈɛləfənt]. In sentence repetition it appeared that the motor planning for the production of two multisyllabic words (ELEPHANT and BANANA) in close proximity had broken down at the level of phonological assembly.

This utterance level variability is further illustrated in the following examples:

1) SAM LOVED TO DANCE realised as

   i. [ˈsæ̃m lʌ̃ lɑ̃ʔn lɑ̃ns ˈlʌns tʰ ə ˈdɑ̃ns]
   ii. [ˈsæ̃m lʌf ˈdʌ̃ns]

Harry again evidenced difficulties with phonological assembly. In the first attempt the utterance final, stressed and accurate realisation of DANCE appears to have interfered with the realisation of the verb LOVED earlier in the sentence. The sequence showed four realisations of LOVED, each one influenced by [ˈdɑ˜ns] in slightly different ways. On his second attempt (having been given the model again), Harry simplified the sentence both syntactically and phonetically, firstly by omitting the past tense morpheme -ED and the verb infinitive marker TO, and secondly by the use of vowel harmony across the two words

2) JOHN COLLECTS STAMPS realised as [ˈgɒ˜n təˈlɛts ˈsæ˜ʔnts], noting the final cluster in STAMPS.

In comparison with an item with a similar coda in the SW data set, JUMP, realised as [dʌ˜mp], all oral consonants in the utterance other than the initial target affricate were realised with appropriate manner of articulation, but with consistent alveolar place of articulation. If the word STAMPS was analysed as a SW using a phonological process approach, this analysis might suggest atypical realisation of bilabial segments; seen in the context of analysis at the level of multi-word speech, the production was more likely to reflect a long domain harmony realised across an utterance.

Traces of similar difficulties appeared occasionally in the spontaneous MWU data: for example, see the repair of the word "sac" in the utterance AND IF THEY'RE REALLY LUCKY THEY MIGHT MAKE (UM) MAKE TWO EGG SACS (CS 6) realised as [æ˜n ɪs ə wiː ˈlʌʔi ɛɪ mãɪ me˜ɪ (ə) me˜ɪʔ ˈtʰ u ɛʔ ˈsʌkː' (...) ˈsæks]; the first realisation of SAC is apparently influenced by the vowel /ʌ/ in the word LUCKY. For the most part, however, they occurred most noticeably in sentence repetition and may be a reflection of the nature of the task which makes particular demands on memory and planning, not permitting the kind of lexical selection and avoidance known to occur in young children's speech development and in developmental speech disorders (see Stoel-Gammon, 2011, for a review).

5.12 Speech behaviours in multi-word utterances T1

Harry's speech production was examined in conversational speech and imitated sentences, focusing on an assessment of the characteristics of his speech at word boundaries and how this compared to the multi-word speech of other children of the same age. Harry's use of assimilation, elision and liaison, and close versus open juncture was examined both in sentence repetition and in conversational speech

5.12.1 Word juncture in sentence imitation T1

The ***Connected Speech Processes (CSP) Repetition task*** (Stackhouse et al., 2007) was carried out to examine word juncture behaviours in imitated sentences (see table 5.9).

Table 5.9 Harry: Scores on Connected Speech Processes (CSP) Repetition task T1

Process	Score expected at age 7	Harry's score	Examples of Harry's realisations compared with typical 7-year-olds
Assimilation			
t#*	92.40 %	0% (0/4)	EAT PUDDING [ˈip˺‿ pʊdɪ˜ŋ]→[ˈiʔ pʊdɪ˜ŋ]
n#	80.43%	25% (1/4)	JANE MADE [ˈʤeɪ˜m me˜ɪd]→[ˈde˜ɪn me˜ɪd]
d#	43.18%	0% (0/4)	RED CAR [ˈɹɛg˺‿ kɑ]→[ˈwɛʔ‿ kɑ]
#ʃ	83.83%	n/a	/ʃ/ was realised as [s], so not possible to score
Elision			
Ct#C	86.94%	50% (2/4)	MUST CLEAN [ˈmʌs klĩn]→[ˈmʌʔ klĩn]
Cd#C	72.63%	100% (10/10)	ROBBED THE [ˈɹɒb ðə]→[ˈwɒʔb ðə]
Liaison			
j-liaison	91.94%	25% (1/4)	MY UNCLE [maɪʲ ˈʌ˜ŋkl]→[maɪ ˈʔʌ˜ŋk]
w-liaison	95.35%	50% (1/2)	BLEW OUT [bluʷ ˈaʊt]→[buʷ ˈaʊʔ]
r-liaison	86.15%	0% (0/4)	CLAIRE ATE [ˈklɛəʴ ɛt]→[ˈklɛə (.) ə ˈʔɛʔ]
Articles			
Indefinite	No norms given	0% (0/2)	AN ELEPHANT [ə˜n ˈɛləfə˜nt]→[əʔ ˈɛləfə˜nt]
Definite	No norms given	0% (0/2)	THE ORANGE [ðiʲ ˈɒɹɪ˜nʤ]→[əʔ ˈɒwɪ˜ns]

*a glottal stop for SFWF /t/ is typical for Harry's accent so was accepted

Harry's scores for elision, assimilation and liaison were, with one exception (elision of word-final /d/), much lower than expected for a child of his age. There were frequent examples of glottal stops at word boundaries with 21 (50%) of the 42 target junctures being realised in this way. Harry used both open and close juncture on this task. For example THE RED CAR WENT AWAY was realised as:

O O O C C
[də ˈwɛʔ ˈkʰ ɑ ˈwɛ˜nt əˈweɪ]

There was open juncture between THE and RED; RED and CAR; CAR and WENT with equal stress on RED, CAR and WENT. The last part of the utterance was realised with close juncture.

There were two instances in the data of atypical elision with SIWI velars being deleted and close juncture replacing the deleted segments with approximant liaison. These were:

- YO<u>U C</u>AN READ MY BOOK realised as [ˈju ʷ æ̃m ˈwib̚ maɪ ˈbʊk]
- H<u>E G</u>AVE ME A BANANA realised as [hi ˈʲ eɪ mi ə bəˈnɑ̃nɑ̃]

These two examples, while being unusual were not probably significant in terms of Harry's speech data overall. However, they provided insight into the hyperelision that was characteristic of Harry's output, discussed in the next section. Replacing adult targets, particularly in SIWI position and in stressed syllables, as with GAVE, is highly unusual (Shockey, 2003) with consequent impact on listener recognition of what has been said.

5.12.2. Word juncture in conversational speech

Having assessed word juncture through sentence repetition, Harry's conversational speech was examined to see how this compared with sentence repetition in terms of the connected speech processes assessed and other word juncture behaviours. In the conversational data there were occasional examples of appropriate close juncture, for example, the use of j-liaison at the boundary between BY and A in the phrase STABBED BY A PERSON (CS 3) realised as [ˈstæʔː baɪʲ ə ˈpʰ ɑsə̃n]. In many instances, however, the connected speech processes of assimilation, elision and liaison which might be expected in typical speech production from around three years old were not apparent in Harry's spontaneous speech. As also found in the Connected Speech Processes Repetition data, many word junctures were produced with glottal stop realisation of SFWF consonants, for example, the target BIG BOX was realised as [ˈbɪʔ bɒks] and STABBED BY as [ˈstæʔː baɪ]. Howard, Wells and Local (2008) describe the ways in which an unusual preference for open junctures at word boundaries, together with a tendency to hyperarticulation of segments, will produce prosodically atypical speech, which may sound "slow, effortful and disjointed" (p. 594). A different effect is found where there is a preference for close junctures; these are realised with inappropriate segmental and syllabic omissions and weak articulation and may reduce intelligibility through hyperelision as with the examples given in section 5.12.1. Hyperarticulation and hyperelision may exist side by side in the speech production of an individual child, and this appears to be the case for Harry in his multi-word speech in conversation.

In some cases Harry used inappropriate open juncture (mainly through the use of audible pauses) within phrases. For example, the phrase AND LANDED ON THE BOAT'S TOP was realised as [æ̃n ˈlæ̃ndɪʔ ɒn (.) d̪ə bəʊts (.) ˈtʰ ɒp], generally preserving the syllabic structure of the words, but at the expense of rate, rhythm and general fluency. There were also occasional examples when he showed other unusual open juncture realisations at word boundaries. For example, the phrase AND (A) COUPLE OF was transcribed as: [ænn̊ (.) tʌ̃ pəz]. Here the audible nasal emission on the latter part of the nasal at the juncture of AND and COUPLE is followed by a perceptible silent interval before the release of the fronted [t] in COUPLE, which is accompanied by velopharyngeal turbulence. Both nasal emission and velopharyngeal turbulence are speech production features most commonly associated with cleft palate speech, however, in Harry's case they provide a clear example of specific difficulties with the timing of velopharyngeal closure in the transition from the word-final nasal to the word-initial homorganic plosive.

Co-existing with utterances evidencing hyperarticulation and open juncture were other utterances characterised by hyperelision. For example, I DIDN'T EVEN in the utterance I DIDN'T EVEN EAT ANY was realised as [aɪ ˈjɪjɪn], and SHALL I TELL YOU WHAT was realised as [ən ˈdæ d̪eːɪ ˈwɒʔʰ] and AND THEN A as [ən neɪ ˜ə]. In these excerpts from the MWU data there are both segmental and syllable elisions, as well as unusual and weakened articulatory realisations. These appear to reflect typical MWU reduction processes (Johnson, 2004) but when interacting with the limitations of his segmental system, processes which should make his speech more typical have counter-productive effects on intelligibility. Examination of the data shows that hyperelision was typically associated with specific linguistic and interactional contexts. It was particularly, but not only, found in high frequency words and phrases. Hyperelision was also a feature of narratives recounting familiar events, where it occurred alongside words and phrases characterised by more careful articulation and more frequent use of open juncture. There was a tendency for the establishment of a specific topic and its referents to be associated with hyperarticulation, with hyperelision being used thereafter, where shared listener knowledge may be assumed. A comparison of two items, one from the SW data and one from conversational speech, serves as a reminder that the phonological, grammatical and lexical structure of an utterance can have a profound effect on segmental sequences which, in terms of sequence alone, might be considered to be identical. Thus in the SW data, Harry produced

ROUNDABOUT as [ˈwaʊ˜ndəbaʊt], with minimal difference from a typical adult target, whereas in the CS data, FOUND ABOUT, in the utterance US FOUND ABOUT 85 GOOSE FEATHERS (CS 4) was realised as [ˈfaʊn (.) əʔ (.) baʊʔ], displaying open juncture at word and syllable boundaries, final consonant deletion, and glottal replacement of /t/.

5.13 The realisation of final plosives as an interactional device

One further observation was that Harry's productions of voiceless and devoiced plosives in word-final context in both the SW and MWU data suggested that realisations were influenced by their position both within an utterance and also in the larger context of conversational interaction. A range of realisations were identified (unreleased plosives, glottal stops, deletions, and ejectives). Closer inspection, however, suggested that the ejective realisations occurred in specific phonological and interactional contexts. Whereas the unreleased plosives, glottal stops and deletions occurred within utterances in the conversational speech data, ejective realisations occurred in both the SW data and the conversational speech data in contexts which were both utterance-final and also signalled the end of a turn constructional unit in the larger interaction (Sacks, Shegloff, & Jefferson, 1974), (see table 5.10 for examples of different variants and their contexts). In other words, they occurred at points where the conversational turn was being handed from Harry to his conversational partner.

Table 5.10 Harry: Ejective and non ejective realisations of plosives in the SW and CS data T1

Phonetic realisation (targets underlined)	Context
PI<u>G</u> [bɪk]; ELEPHAN<u>T</u> [ˈɛləfənt']	SW: utterance final
BI<u>G</u> GROU<u>P</u> [ˈbɪʔ ˈgwup']	CS 5: within utterance (BI<u>G</u>) and utterance final (GROU<u>P</u>)
OR MAYBE GO<u>T</u> STABBE<u>D</u> BY A PERSON OR SHO<u>T</u> [ɔ ˈmeɪbi̦ dɒʔ ˈstæʔ baɪʲ ə ˈpʰ ɑsən (.) ɔ ˈsɒt˙]	CS 3: within utterance (GO<u>T</u>, STABBE<u>D</u>) and utterance final (SHO<u>T</u>).
GOOSE FEATHERS CAME U<u>P</u> AND THEN A BI<u>G</u> WAVE CAME AND WASHE<u>D</u> I<u>T</u> U<u>P</u> [ˈdus ˈfɛzəz ˈteɪ˜m ʌp˺ ə˜nʊ˜ə ˈbɪʔ ˈweɪ ˈkʰ ɛ˜ːm ə˜n ˈwɒst ɪʔ ˈʌp']	CS 4: within utterance (U<u>P</u>; BI<u>G</u>; WASHE<u>D</u>; I<u>T</u>) and utterance final (U<u>P</u>)
I LI<u>K</u>E THE CRUS<u>T</u> OF THE BREA<u>D</u> [ʔaɪ ˈlaɪʔ ðə ˈtʰ ʌ_st ɒz͡ . ə ˈbw̤ɛt]	CS 2: within utterance (LI<u>K</u>E; CRUS<u>T</u>) and utterance final (BREA<u>D</u>)

The realisation of plosives as ejectives may not impact on intelligibility in conversational speech, indeed they occur in typical speech (Ball & Mu¨ller, 2005), but listeners may notice their occurrence in Harry's speech. However, significantly for clinical interpretation, a speech assessment that is confined to single word production only may lead to the erroneous conclusion that Harry has atypical realisations of SFWF plosives; Ball and Müller (2005) comment that occasionally ejectives occur in articulatory disorders. Alternatively, if single word realisations are compared with productions of the same segments in conversation, a somewhat different picture emerges. The picture-naming task could be regarded as a particular type of interaction between child and his conversational partner with each instance of single word production interpreted as, in itself, a turn end (Wells, 2010, personal communication). The interactive role of ejective realisations is highlighted by the pattern of occurrence at "turn end" in both SW and conversational speech but it is only through comparison of the SW and multi-word speech data that a pattern can be detected.

5.14 Summary of findings at T1

Harry's input processing skills and speech output skills at T1 were summarised as follows: (see also his speech processing profile in appendix 5.2 and 5.3 for the mapping of this profile to the speech processing model).

- Input processing skills showed a range of difficulties in the discrimination and judgement tasks at SW level particularly involving non-words rather than real words and when items had complex segmental and syllabic sequences
- Scores for the auditory lexical decision task were within the normal range suggesting underlying phonological representations for these items were accurately defined
- Harry had difficulties with speech discrimination at sentence level, judging SIWI consonant clusters and SFWF fricative targets; these reflected phonological processes that occurred in his speech output
- Harry had severe level of difficulties with speech output as measured by a naming task, a non-word repetition task and a real word repetition task; he showed the same speech output patterns across all three types of stimuli suggesting that similar perceptual and articulatory constraints affected output in all three testing conditions

- Harry's performance on oro-motor tasks suggested that he had some difficulties with precision and power in non-speech movements
- Scores on the DDK task indicated significant difficulties with motor planning and/or execution
- His phonetic inventory included a reduced number of English consonant phones
- His vowel inventory included all appropriate English vowels
- Harry's SW PCC was 62.11% and his PVC was 95.83%, giving a PPC of 78.97% corresponding to a moderate to severe level of difficulty
- Findings from the phonological processes analysis of Harry's speech were that he had multiple structural and systemic processes including both typically delayed patterns (velar fronting; cluster reduction) and atypical patterns (SFWF labiodental fricatives)
- There was a significant degree of variability in Harry's speech which did not appear to be progressive
- At utterance level he showed interactions between lexical items suggestive of problems with phonological assembly (as with the ELEPHANT and BANANA example, section 5.11.2)
- Harry's management of word juncture was both immature and unusual; he was developing some typical speech behaviours (for example, liaison between vowels at word boundaries) but he had frequent pauses and over use of glottal stops
- He demonstrated both hyperarticulation and hyperelision, and the latter interacting with his segmental difficulties impacted on his intelligibility even for a familiar listener

This leads to the exploration of the impact of these difficulties on Harry's intelligibility as experienced by the listeners who participated in the study.

5.15 Intelligibility T1

Harry's intelligibility was measured through listener responses to an orthographic write-down task for single words, imitated sentences and conversational speech (as described in Chapter Three, Methods); results are presented in table 5.11. Stimuli from Harry's speech output that were presented for intelligibility rating are given in full in appendix 5.12 and in tables 5.19, 5.20 and 5.21.

Table 5.11 Harry: Intelligibility outcomes T1

Data type	Mean % (No.)	Standard deviation % (No.)	Minimum score % (No.)	Maximum score % (No.)
Single words (max no. = 11)	59.78 (6.58)	15.71 (1.72)	27.27 (3)	90.91 (10)
Imitated sentences (max no. = 28)	64.23 (17.98)	14.09 (3.94)	28.57 (8)	100 (28)
Conversational speech (max -= 100%)	54.12	15.68	21.88	87.50

Analysis of results using the Wilcoxon Signed Ranks Test demonstrated that listeners' identification of Harry's conversational speech was poorer than single words ($Z=-2.102$, $p=<.036$) but the intelligibility of imitated sentences was better than both SW ($Z=-2.527$, $p=<.012$) and conversational speech ($Z=-4.495$, $p<.0001$).

There was a wide range of listener response to all types of stimuli as demonstrated by the large standard deviations and minimum and maximum scores. In terms of the individual stimuli items, in SW GLOVES was least well recognised with 0/66 listeners identifying it; BOOK was best with 66/66 correct responses. The least well recognised imitated sentence was SHE GAVE (THE) ORANGE TO SAM with 32.83% of words identified. The best was CLAIRE ATE ALL HER LUNCH with 94.19% of words identified. In conversational speech 'COS THEY'RE SHARP was least well recognised, with 15.15% of words identified; the best was HOW DO YOU THINK HE DIED with 82.58% of words identified. These intelligibility results are discussed in section 5.26.5.

5.16 Activity between T1 (7;5) and T2 (8;5)

Between this first assessment and the second one twelve months later, Harry participated in weekly intervention sessions together with regular follow-up sessions with his school teaching assistant. Intervention focused on establishing /ʃ, ʧ, ʤ/, consistent use of clusters in multi-word speech, and perception of speech sound sequences and production of high frequency multi-syllable words. Activities to develop self-monitoring skills using a digital voice recorder for feedback were included as were phonological awareness tasks to develop skills such a rhyme, blending and segmentation.

At the end of this period of intervention Harry's speech was reassessed.

5.17 Assessment T2 (C.A. 8;5)

Twelve months after the first assessment at T1 Harry's input processing skills and speech output skills in single words and multi-word utterances were reassessed (see appendix 5.13 for his new speech processing profile and 5.14 for the mapping of this profile to the speech processing model). The aim of this reassessment was to collect sufficient data to describe any significant changes in Harry's speech output and speech processing and also to examine his intelligibility at T2 as judged by the listeners (see Chapter Three, Methods).

5.18 Input processing skills T2

The investigation of Harry's input processing skills included assessment tasks from Stackhouse, Vance, Pascoe and Wells (2007) and other non-standardised activities.

- Discrimination between same/different SFWF single features and s-cluster sequences in real words and non-words, for example, lost/lots; vost/vots, (Stackhouse et al., 2007). At T1 Harry's overall number correct was 33/36, z=-2.84, indicating difficulties which were particularly related to non-word discrimination. At T2 Harry scored 35/36 (no norms were available for his age group). He made frequent requests for repetition before responding but the difference between real word and non-word discrimination appeared to have resolved.

- Discrimination of segmental differences between pairs of complex non-words, for example, /gə ˈtɔ/ /tə ˈgɔ/, (Stackhouse et al., 2007). At T1 Harry had shown difficulties in this task scoring 67.5% (27/40), z=-3.08. At T2 he scored 87.5% (35/40), z=-0.42 and his performance was now within the typical range for a child of his age.

- Three minimal pair contrasts from the Auditory Lexical Decision task (words in sentences), (Stackhouse et al., 2007) were re-examined; MOUSE/MOUTH, score 100%, (12/12); GLASS/GRASS, score 97.22% (35/36); CLOWN/CROWN, score 72.77% (26/36).

At T1 these scores were 77.77% (28/36), 41.66% (15/36) and 77.77% (28/36) respectively. Two of the three contrasts had improved in terms of the percentage score correct. Harry continued to show difficulty in discrimination of liquids in the CLOWN/CROWN pair.

- Test of Phonological Awareness (Hatcher, 1994) (see table 5.12): Harry showed progress in rhyme identification and phoneme segmentation but still had difficulty with the most complex tasks involving phoneme deletion and transposition.

Table 5.12 Harry: Hatcher Test of Phonological Awareness T1 and T2

Task	Example	Score T1	Score T2
Syllable blending	What am I saying? "win-dow" (window)	6/6	6/6
Phoneme blending	What am I saying? "s-ou-p" (soup)	5/6	6/6
Rhyme	Which one doesn't rhyme? Dog, pot, log (pot)	4/6	6/6
Phoneme segmentation	How many sounds? "pet" (3)	2/6	5/6
Phoneme deletion	What's the word if you take "g" away from "gone" (on)	0/6	1/6
Phoneme transposition	What is "net" backwards (ten)	1/6	0/6

Overall, Harry's input processing skills showed positive progress, although his performance showed residual difficulties in tasks involving perception of complex segmental sequences. His phonological awareness skills in terms of manipulating sounds in words were still insecure. His teacher reported that the development of his literacy skills was significantly delayed in comparison to that of his peers.

5.19 Speech output tasks T2

Harry's speech production was re-assessed using a range of single word tests as at T1; the Picture Naming Task (Stackhouse et al., 2007), the Non-word Repetition Task (Stackhouse et al., 2007), the Real Word Repetition Task (Stackhouse et al., 2007) and subtests of the DEAP (Dodd et al., 2002) giving 110 items collected from these tasks for single word (SW) analysis which was the same as at T1 (appendix 5.4). The multi-word data are from the analysis of T2 conversational speech (CS) (appendix 5.15) and selected imitated sentences from the Connected Speech Processes (CSP) Repetition Task (Stackhouse et al., 2007), (see table 5.20); there are occasional examples from other conversational speech, which are indicated in the text.

Harry's performance on the Picture Naming Task (Stackhouse et al., 2007) and the Non-Word Repetition Task (Stackhouse et al., 2007) were scored, and in the absence of norms for 8-year-olds, compared to that expected in the speech of typical 7-year-olds; scores were also compared with T1 (see table 5.13).

Harry's overall score across all word lengths, z=-5.64, indicted a severe level of difficulty even when compared with a typical 7-year-old and he was now 8;5. The percentage of whole words correct had improved from 21/60 (35.00%) to 32/60 (53.33%) but a typical peer would be achieving over 90% correct. Scores across all word lengths were impaired but multisyllabic words in particular were influenced by gliding, arguably a relatively minor process in terms of intelligibility (Hodson & Paden, 1981). Single syllable words were affected by gliding and also deaffrication

Table 5.13 Harry: scores Picture Naming and Non-Word Repetition Tasks T1 and T2

	Picture Naming Task (real words)			Non-word Repetition Task		
Word structure	Harry's score T1 (z-score)	Harry's score T2 (z-score)	Real word norms age 7 years mean (S.D.)	Harry's score T1 (z-score)	Harry's score T2 (z-score)	Non-word norms age 7 years mean (S.D.)
1 syllable (N=20)	9 (-8.16)	12 (-5.66)	18.8 (1.20)	9 (-3.75)	16 (-0.02)	16.05 (1.88)
2 syllable (N=20)	8 (-8.16)	12 (-5.03)	18.45 (1.28)	8 (-4.71)	15 (-1.02)	16.95 (1.90)
3 & 4 syllable words (N=20)	4 (-5.55)	8 (-3.84)	16.95 (2.33)	8 (-3.34)	11 (-2.06)	15.80 (2.33)
Total (N=60)	22 (-8.44)	32 (-5.64)	54.2 (3.93)	25 (-5.11)	42 (-1.46)	48.85 (4.66)

Harry's score for non-word repetition across all word lengths had improved and this was particularly evident with 1 and 2 syllable words. Longer words (3/4 syllables) still showed some difficulties with a z-score of -2.06 in comparison with typical 7-year-olds. His total number correct for repetition of non-words was 42/60 (70%) compared with 25/60 (41.66%, z=-5.11) at T1. A difference between the percentage scores for non-word repetition (70% correct) and real word naming (53.33% correct) had developed by T2. This difference was largely due to more accurate production of affricates and post-alveolar fricatives in non-words.

Because naming real words and non-word repetition scores showed a large difference, the Real Word Repetition Task (Stackhouse et al., 2007) was carried out. (This was not done at T1). Harry scored 49/60, 81.66%, z=-1.42, compared with a typical 7-year-old, which was in the average range for that age group. Scores for words of different lengths showed some differences with 1 syllable (z=-4.12) and 3/4 syllable (z=-3.16) showing difficulties, and 2 syllable (z=0.44) being a typical score. Scores for non-adult realisations were again largely derived from gliding and deaffrication.

Overall the performance on these three tasks showed that Harry had made progress between T1 and T2. The difference between naming and repetition of both real words and non-words was a positive indicator for change in that Harry's production was more accurate when given a direct model and this had not been in evidence at T1.

This progress was also seen in terms of the overall percentage correct in the production of consonants and vowels. Harry's PCC was 79.50% (62.11% at T1) and his PVC was 98.94% (95.83% at T1), giving a PPC of 89.21% (78.97% at T1). Scores were based on 110 single words taken from the DEAP (Dodd et al., 2002) phonology, inconsistency and articulation tests and the Picture Naming Task. His severity rating for consonant production (Shriberg and Kwiatkowski, 1982) progressed from a moderate to severe level at T1 to a mild to moderate level at T2.

5.20 Oro-motor skills and diadochokinesis (DDK) T2

Harry's oro-motor skills were reassessed using items from the DEAP (Dodd et al., 2002). His ability to imitate lateral tongue movements had improved with more accuracy and precision, but he was still not able to elevate his tongue tip to command.

The DDK task also showed improvement in that Harry was able to produce 50% of the 10 [p-t-k] sequences accurately (none were accurate at T1) but he still lacked fluency with frequent hesitations between sounds.

These findings suggested that Harry still had difficulties with both oro-motor movements and motor planning.

5.21 Phonological process analysis T2

A phonological process analysis was again completed using data primarily from single words and conversational speech, supplemented by data from imitated sentences.

The scores from speech output tasks (section 5.19) demonstrated that there had been positive changes in Harry's speech in the year between assessments, however, comparison of words elicited in these naming tasks at T1 and T2 also indicated the persistence of both structural and systemic features (see table 5.14).

Table 5.14 Harry: Comparison of selected SW at T1 and T2

Target	Harry's realisation T1 (7;5)	Harry's realisation T2 (8;5)	Comments
AEROPLANE /ˈɛərəpleˆɪn/	[ˈɛələpeɪˆn]	[ˈɛələpeˆɪn]	No change
BREAD /brɛd/	[ˈbwɛtʼ]	[bwɛt̚]	No change
BRUSH /brʌʃ/	[bwʌs]	[bwʌs]	No change
CARAVAN /ˈkærəvæˆn/	[ˈtʰ æləbæˆn]	[ˈkʰælivæˆn̚]	SIWI velar fronting resolved
CHAIR /ʧɛə/	[tʰ ɛə]	[ʧɛə]	SIWI deaffrication resolved
FEATHER /ˈfɛðə/	[ˈfɛzə]	[ˈfɛvə]	SIWW fronting of alveolar fricative realised in more typical form
FISHING /ˈfɪʃɪˆŋ/	[ˈfɪsɪˆn]	[ˈfɪʃɪˆŋ]	SIWW post-alveolar fronting resolved
PARACHUTE /ˈpærəʃut/	[ˈpʰ æləsutʼ]	[ˈpʰ æwəʃutʼ]	SIWW post-alveolar fronting resolved
TOOTHBRUSH /ˈtu θ brʌʃ/	[ˈtʰ uʔbʌ̰s]	[ˈt̪ ufbwʌ̰s]	SIWW cluster reduction resolved
UMBRELLA /ʌˆmˈbrɛlə/	[ʌˆmbəˈwɛlə]	[ʌˆmbəˈwɛlə]	No change

5.21.1 Structural processes T2

The most pervasive structural process in Harry's speech at T1 had been cluster reduction and this had reduced between T1 and T2, particularly in single words. SIWI and SIWW clusters in SW were examined; 30.3% (10/33) were anyway realised accurately at T1, 36.36% (12/33) showed development at T2 (24.24%, 8/33 of these were now accurate) and 33.33% (11/33) were unchanged. Gliding of /r/ impacted on cluster realisation and this remained a consistently used process in naming tasks although in repetition of non-words the more mature variant was sometimes produced.

In conversational speech the realisation of consonant clusters was subject to more variability than in SW. So, for example, (CS 1, T2) in the utterance THIS IS ME-DRIVING realised as [ðɪs ɪz̥ ˈmĭ (.) ˈdɹaɪvə˜n], the cluster /dr/ was produced in a typical form. The next utterance included FROM THE FLOOR TO HERE realised as [fɒ˜m ə ˈfɔ tə ˈhɪə] with reduction of both clusters /fr/ and /fl/. In SW he had produced /fl/ in FLOWER as [ˈflaʊwə] at both T1 and T2 but at T1 in CS it was reduced to /f/ in the word FLY; the target /fr/ was reduced to a single element in both SW and CS at T1 but by T2 it was realised with epenthesis and a glide in SW, FROG [fə˘wɒk']. In CS at T2 both were realised as [f].

5.21.2 Systemic processes T2

By T2 there was progress in relation to systemic processes. There was only one example of velar fronting in either SW or conversational speech (GUITAR realised as [dɪ˘ˈtɑ], which had been [bɪ˘ˈtɑ] at T1). However, devoicing of word final plosives and fricatives was in evidence as it had been at T1 with one exception, the realisation of FIVE with SFWF /v/ appropriately voiced. Voicing of segments within single words appeared to be more typically realised so, for example, MONKEY, previously [ˈmʌ˜ŋg̥i] was [ˈmʌ˜ŋki] and BISCUITS, previously [ˈbɪʔgɪt'] was realised as [ˈbɪʔkɪtsː]. However, variability was still evident in conversational speech for example, I WAS SWEATING BUCKETS realised as [ʔɒs⁀ sfɪ˜ŋ ˈbʌgɪt̪s], with voicing of the SIWW velar plosive in the word BUCKETS. The combination of atypical voicing and an ongoing tendency to realise within-word alveolar and velar plosives as a glottal stop had an impact on word prosody. For example, in the utterance IT WAS LIKE-ALWAYS MIDNIGHT realised as [ɪʔ wəɹ̥ ˈlaɪʔ ɔˈweɪ˜ ˈmɪʔnãɪʔ] the perceptual impact of the glottal stop on the preceding vowel was that the duration of an already short segment was further shortened.

Harry's realisation of post-alveolar and affricate segments had developed. In SW he produced them accurately and consistently in SIWI positions (8/8); in SIWW positions this accuracy was at 60% (3/5) but he never realised post-alveolar and affricate segments in SFWF positions (0/9). This pattern was repeated in multi-word utterances, for example, ABOUT THREE HOURS JOURNEY TO IT was realised as [ˈbaʊʔ ˈfwiʲ aʊz̥ ˈʤɜni tuʷ ˈɪʔ], with the SIWI voiced affricate [ʤ] being produced in the mature form. In sentence imitation he realised the target CLAIRE ATE ALL HER LUNCH as [ˈklɛəː ɔʊ hə ˈlʌ˜ntsː] with an immature form of the adult SFWF /ʧ/.

Other progress was noted where Harry no longer realised labiodental fricatives as alveolar fricatives, for example, FIVE was realised as [faɪv̥]. However, the post-alveolar approximant /r/ continued to be realised as the glide [w]. Harry's progress in the use of adult target forms was not yet generalised across all types of utterances. Further examples of non-adult structural and segmental realisations are given in table 5.15 comparing production at T1 and T2 and illustrating where the progress noted in SW was not evident in conversational speech.

Table 5.15 Harry: Examples of non-adult structural and segmental realisations in CS compared with SW T1 and T2

Target T2	Harry's realisation T2	Comparison with SW T2 and T1
YEH-I WAS SWEATING BUCKETS	[ˈjɛ ʔɒs˜ sfɪ˜ŋ ˈbʌgɪts̺]	/sw/→[sf]; compare with [sfɪ˜nh] (SWING, SW T1) and [swɪ˜ŋ] (SWING, SW T2) SIWW /k/→[g]; compare with [ˈbɪʔgɪt'] (BISCUIT, SW T1) and [ˈbɪʔkɪtsː] (BISCUITS, SW T2)
NOPE, IT'S A CARAVAN	[ˈnə˜ʊp' ɪts̺ ə ˈkʰæː˜əbæ˜n̤]	SIWW /v/→[b]; compare with [ˈtʰ æləbæ˜n] (SW T1) and [ˈkʰ ælivæ˜n̺] (SW, T2)

In the first example Harry realised the target cluster /sw/ with consonant harmony as [sf] in SWEATING as it had been at T1; in SW (T2) this was realised correctly. He also reduced the word from two syllables to one. In the second example, the SIWW target /v/ in CARAVAN was realised as the immature form [b] which was the same as T1, although the WI velar was not fronted as it had been at previously. Analysis of these examples suggests that at T2 Harry's multi-word utterances were still affected by various phonological processes which had showed progress towards mature forms in SW.

5.22 Features not captured through phonological process analysis T2

As at T1, the phonological process analysis revealed a wealth of information which contributed to the description and explanation of Harry's speech patterns and intelligibility. However, a wider analysis was necessary in order to re-examine the other features such as the atypical realisation of multisyllabic words which could not be accounted for through a traditional phonological process analysis approach. In addition word juncture behaviours in multi-word utterances were explored.

In spite of the positive changes in Harry's speech, the overall impression of atypical segmental and prosodic features was still in evidence, albeit with reduced frequency. Habitual "frozen" forms were largely unchanged, so for example, a frequently used sequence was APART FROM realised as [ɪmˈpɑʔ fɒm]. Harry's realisation of segmentally complex multisyllabic words still evidenced unusual phonetic and sequential realisations. For example, the utterance AND THE MOST HANDSOMEST BOY, realised as [æ̃n ðə ˈmə̃ʊs ˈhæ̃msəd̪ɪv ˈbɔɪ] illustrates this type of sequence which does not conform to any predictable pattern.

One important change was that the variability in Harry's speech, which at T1 had not necessarily been progressive, had significantly reduced, particularly in single words.

5.23 Word juncture in multi-word utterances T2

As at T1, Harry's use of assimilation, elision and liaison, and close versus open juncture was examined in sentence repetition and in conversational speech. This was first explored using the Newton Sentences Connected Speech Processes (CSP) assessment (Stackhouse et al., 2007), (see table 5.16). Normed scores were available only up to the age of 7; Harry's results were compared to these and to scores at T1.

Table 5.16 Harry: Scores on CSP task T1 and T2

Process	Harry's score (%) T1	Harry's score (%) T2	Score expected at age 7 (%)
Assimilation			
t#	0 (0/4)	75 (3/4)	92.40
d#	25 (1/4)	75 (3/4)	80.43
n#	0 (0/4)	25 (1/4)	43.18
#ʃ	0 (ʃ not realised)	100 (2/2)	83.83
Elision			
Ct#C	50 (2/4)	75 (3/4)	86.94
Cd#C	100 (10/10)	70.00 (7/10)	72.63
Liaison			
j-liaison	25 (1/4)	100 (4/4)	91.94
w-liaison	50 (1/2)	50 (1/2)	95.35
r-liaison	0 (0/4)	25 (1/4)	86.15
Articles			

Indefinite	0 (0/2)	50 (1/2)	No norms given
Definite	0 (0/2)	50 (1/2)	No norms given

In this sentence imitation task Harry showed the emergence of mature forms at T2 with assimilation and elision; there were fewer open junctures and a reduction in glottal stops in SFWF positions. /j/-type liaison was well developed (for example, [mãɪʲ ʌ˜ŋkl̩], /w/ and /r/ less so in the items tested. Harry was beginning to use definite and indefinite articles which had previously been produced as undifferentiated forms.

At T1 Harry had shown some significant output planning difficulties at utterance level in this task and although the presentation was arguably more subtle, these difficulties were still clearly in evidence at T2 (table 5.17).

Table 5.17 Harry: Selected examples of speech production in CSP task, T2

	Target	Harry's realisation
1	THE BROWN BEAR EATS THE FISH	[ˈbwɑʊm ˈbwɛə] (two attempts)
2	JOHN COLLECTS STAMPS	[ˈʤɒ˜ns kəlɛt]
3	YOU MUST STIR IN THE SUGAR	[ˈju mʌ˜s ˈʃɜʴ ɪn ðə ˈsʊgə]

In the first example, the consonant cluster [bw], Harry's realisation of /bɹ/, is produced SIWI in both BROWN and BEAR and, in spite being given a second model and asked to try again, he was not able to change this. In the second example, third person singular -s was produced SFWF on the name JOHN instead as a tense marker on the verb. On the third example the segments /s/ and /ʃ/ in syllable onset positions were transposed and the plosive element of the /st/ cluster was omitted.

In conversational speech the development of word juncture behaviours seen in sentence imitation was also evident. For example, the use of liaison between SFWF and SIWI vowels in the utterance ABOUT THREE HOURS JOURNEY TO IT realised as [ˈbaʊʔ ˈfwiʲ ɑʊz̩ ˈʤɜni tuʷ ˈɪʔ]. There was also one example of assimilation as in WHEN WE GOT THERE (CS 1, T2) realised as [ˈwɛ˜m wi ˈgɒʔ ðæ] with the SIWI bilabial approximant influencing the preceding SFWF alveolar. There were no lexical sites where it was possible for word boundary elision to occur. Wider examination of Harry's conversational speech was done by reviewing the entire first session at T2 (where the transcribed data were taken from); this revealed occasional examples of assimilation as in THROWING BOWLS realised as [ˈfəʊə˜m ˈbəʊlz̩]. However, there were no instances of elision at word boundaries, again possibly because of the paucity of, for example, regular past tense verbs. It was rather the case that hyperelision both within words and across longer stretches of utterance affected output. Harry's conversational output was still atypical prosodically. There were a few examples of quite slow and dysfluent speech which appeared to relate to difficulties in formulation, so for example, at the start of the utterance just discussed, IT WAS-WELL-ABOUT THREE HOURS JOURNEY TO IT realised as [ɪ ͡wəz (.) wəʊ (.) ˈbaʊʔ ˈfwiʲ ɑʊz̩ ˈʤɜni tuʷ ˈɪʔ], there was hesitation between WAS and then WELL and ABOUT (WELL appeared several times as a filler). However, more frequently, the hyperelision that had been so evident at T1 was still present and one striking feature about Harry's conversational speech was that his intelligibility, at times, remained poor.

Given the assertion that persistence of non-adult segmental realisations alongside typical reduction in multi-word utterances impacted on Harry's intelligibility, the multi-word data were again examined to consider what was and was not intelligible to the author, who by T2 was very familiar with Harry's speech. This examination indeed showed several stretches of utterance that were unintelligible, for example, AND THAT'S RATHER MESSY SO (X XX) WE (X XX X X) IT VERY WELL , realised as {V‿ æ̃n ˈðæts ʋ̣ɑvə ˈmɛsi (X XX) wi (X XX X X) ɪʔ ˈwɛwi ˈwɛʊ V‿}. As noted at T1, these sections tended to be mid utterance and mid-topic, positions which may be more liable to reduction than at the beginning of a conversation or when establishing a new topic.

5.24 Summary of findings T2

Assessment at T2 demonstrated convincing evidence of changes in Harry's speech production. This was measured through a variety of tasks including PCC where he scored 79.5%, compared with 62.11% at T1 and the Picture Naming Task (Stackhouse et al., 2007) where his level of difficulty as measured by z-scores had reduced. Potentially importantly for prognosis Harry's scores in non-word imitation tasks were within the typical range at least for 7-year-olds, for 1 and 2 syllable words. Although his speech output continued to be affected by both structural and systemic processes, particularly in multi-word utterances, some of the processes still in evidence such as gliding and deaffrication were those which are developmentally later to resolve in typical children. However, atypical phonetic and prosodic factors continued to affect his conversational speech and at times he was still unintelligible.

Harry continued to have oro-motor and motor planning difficulties as evidenced by the oro-motor and DDK tasks. Although his speech perception skills had improved, he still showed residual immaturities in, for example, identification of words differentiated by consonant clusters at sentence level. He had ongoing problems with phonological awareness tasks requiring manipulation of speech sounds in words. His profile of skills indicated that he had ongoing and multiple deficits in both input and output processing skills.

The changes in Harry's speech, and the impact of his ongoing difficulties were explored through his intelligibility as experienced by the listeners who participated in the study.

5.25 Intelligibility T2

Harry's intelligibility at T2 was measured in the same way as at T1 (see Chapter Three, Methods). The same 10 SW and 5 imitated sentences recorded at T1 were recorded again at T2 and edited for the intelligibility task; the conversational speech samples from T2 were obviously different. Results for T1 and T2 were compared (see table 5.18).

Table 5.18 Harry: Intelligibility outcomes T1 compared with T2

Data type	**T1 Mean % (No.)**	T1 S.D.% (No.)	T1 Min score% (No.)	T1 Max score% (No.)	**T2 Mean % (No.)**	T2 S.D. % (No.)	T2 Min score % (No.)	T2 Max score % (No.)
Single words (max no. = 11)	**59.78 (6.58)**	15.71 (1.72)	27.27 (3)	90.91 (10)	**64.14% (7.70)**	13.63 (1.63)	33.33 (4)	91.67 (11)
Imitated sentences (max no. = 28)	**64.23 (17.98)**	14.09 (3.94)	28.57 (8)	100 (28)	**62.22 (17.42)**	12.71 (3.56)	35.71 (10)	82.14 (23)
Conversation-al speech (max = 100%)	**54.12**	15.68	33.33	87.50	**82.17**	9.61	48.84	95.35

Analysis of results using the Wilcoxon Signed Ranks Test demonstrated that the listeners' recognition of Harry's single words at T2 compared to T1 (see table 5.18) had improved although this was not significant ($Z=-1.824$, $p<.068$). Results for conversational speech showed a highly significant improvement ($Z=-7.037$, $p=<.0001$). Conversely results for imitated sentences showed no significant change ($Z=-1.107$, $p=<.268$). The relationship between the different types of speech samples had changed with the identification of imitated sentences at T2 being significantly worse than conversational speech ($Z=-7.037$,

$p<.0001$), as was recognition of SW ($Z=-6.718$, $p<.0001$). At T1 there had been a difference between imitated sentences and SW, in favour of imitated sentences but at T2 this difference was no longer significant ($Z=-.952$, $p<.341$).

The range of listener responses remained very wide for all types of stimuli. For example with SW one listener (L52) recognised only 4 of 11 words and one (L32) recognised them all. Fifteen listeners identified more than 90% of Harry's conversational speech, while three identified less than 60%.

Responses to individual items also varied. In single words the least well-recognised was CRAB (21/66) and most correctly identified words were CHAIR and SPLASH, all 66 listeners recognised these words (see table 5.19); the items were different to those most and least well-recognised at T1.

In sentence imitation the least well identified was THE BROWN BEAR EATS FISH (30.30%) and the most frequently correctly identified item was MARY'S SHOES ARE CLEAN (94.95%). These items were different to those most and least well identified at T1 (see table 5.20). To measure how well MWU were recognised the total number of words in each utterance was multiplied by the number of listeners and the percentage of correctly identified words was calculated (see table 5.20 and 5.21).

Table 5.19 Harry: Individual single words from intelligibility task T1 and T2

Word	Adult target	**Harry's realisation T1**	Number of words identified by individual listeners T1	**Harry's realisation T2**	Number of words identified by individual listeners T2
BOOK	/bʊk/	[bʊk']	66/66	[bʊk']	53/66
CHAIR	/ʧɛə/	[tʰ ɛə]	30/66	[ʧɛə]	66/66
CRAB	/kræb/	[t̼wæp']	17/66	[kwæp']	21/66
GLOVE	/ɡlʌv/	[gəlʌp]	0/66	[glʌṿs]	61/66
LEGS	/lɛgz/	[lɛks]	83/132*	[lɛks̬]	44/132*
LIGHTHOUSE	/ˈlaɪthaʊs/	[ˈlaɪt̚haʊs]	61/66	[ˈlaɪʔhaʊs]	52/66
ORANGE	/ˈɒrɪ˜nʤ/	[ˈɒwɪs]	63/66	[ˈɒwɪ˜nẓ]	34/66
SPLASH	/splæʃ/	[spæs]	28/66	[splæs]	66/66
THANKYOU	/ˈθæ˜ŋkju/	[ˈfæ˜ŋ̰ku]	66/66	[ˈfæ˜ŋkjuː]	23/66
WATCH	/wɒʧ/	[wɒts]	20/66	[wɒʔt͜sː]	28/66

*Score 1 for lexical item and 1 for plural morpheme

Table 5.20 Harry: Individual imitated sentences from intelligibility task T1 and T2

Target sentence	**Harry's realisation T1**	Percentage of words recognised by individual listeners T1	**Harry's realisation T2**	Percentage of words recognised by individual listeners T2
GOOD GIRLS ARE NICE	[ˈgʊʔ dɛ˘ʊz. ə ˈnaɪs]	50.61%	[ˈgʊʔ gʊz ɑ ˈnaɪsː]	66.36%
(THE) BROWN BEAR EATS FISH	[ðə ˈbaʊ˜n bɛ ˈʔits ə ˈfɪsː]	61.42%	[ˈbaʊ˜m ˈbwɑʊ˜ː ˈwɛə ʔits ˈfɪs]	30.30%
CLAIRE ATE ALL HER LUNCH	[ˈklɛːəʔ ɛʔ ˈɔ hə ˈlʌ˜nts]	94.19%	[ˈklɛəː ɔʊ hə ˈlʌ˜ntsː]	74.24%
SHE GAVE (THE) ORANGE TO SAM	[si ˈdeɪz. ə ˈʔɒwɪ˜ns d̥ə ˈsæ˜m]	32.83%	[si ˈgeɪv ˈnɒwɪ˜n ˈtʰ u ˈsæ˜m]	40.66%
MARY'S SHOES ARE CLEAN	[ˈmɛwiz. ⁀ˈsuz ɑ ˈklĩn]	79.29%	[ˈmɛwiʃ ⁀ˈʃuz ə ˈklĩn]	94.95%

In conversational speech (see table 5.21) the least well recognised utterance at T2 was WELL-IT WAS LIKE ALWAYS MIDNIGHT with 41.16% of words identified and the best was YEAH AND THEY GOT TWO-THREE CHILDREN (98.27%).

Table 5.21 Harry: Analysis of conversational speech samples from intelligibility task T1 and T2

Target sentence	**T1 or T2**	**Harry's realisation**	**Percentage of words identified by individual listeners**
'COS THEY'RE SHARP	T1	[ˈtʰ ɒs ɛə ˈsɑp']	15.15%
GOT TO BE CAREFUL OF SCISSORS DON'T YOU	T1	[dəd̪ə bi ˈtʰ ɛəfʊː ˈsɪz.əz. ˈdəʊ˜ nju]	67.42%
HOW DO YOU THINK HE DIED?	T1	[ˈhɑʊ d̪ʉ̈ jʉ̈ ˈfɪŋki ˈd_aɪd]	82.58%
OR MAYBE HE HAD (A) HEART ATTACK	T1	[ɔɪ ˈme˜ɪbi (i) jæd ə ˈhɑʔ ˈtʰ æk]	66.16%
OH THERE'S (A) FUNERAL IN (THE) CHURCH ISN'T THERE?	T1	[əʊ ˈjɛs ə ˈfʊ̈nəbəl ɪ˜n ə ˈtʰ ɑts ɪ˜n, jɛ˜ə]	29.92%
SO ALL TOGETHER IN (THE) WHOLE FAMILY THERE'LL BE 5 CHILDREN	T2	[səʊ ˈɔʊ təˈgɛvəʷ ɪ˜n ə ˈhəʊl ˈfæ˜mli əɫ bi ˈfaɪv. ˈʧɪʊdɹə˜n]	98.76%
WELL IT WAS LIKE-ALWAYS MIDNIGHT	T2	[ˈwɛʊ ɪʔ wəɹ̥ ˈlaɪʔ ɔˈweɪ˜ ˈmɪʔnãɪʔ]	41.16%
WELL THEY BASICALLY HAD (A) SPARE ONE THAT THEY BROUGHT FROM THEIR BOAT	T2	[ˈwɛʊ ðeɪ ˈbeɪsɪʔi hæt' ə ˈspɛə wʌ˜n ðæʔ ðeɪ ˈbɹɔʔ	86.49%

		fwə˜˘m ðɛə ˈbəʊt’]	
WELL, (A)BOUT 3 HOURS JOURNEY TO IT	T2	[wəʊ (.) ˈbaʊʔ ˈfwi^{j} ɑʊz̥ ˈʤɜni tu^{w} ˈɪʔ]	79.65%
YEAH AND THEY GOT TWO-THREE CHILDREN	T2	[ˈjɛ æ˜n eɪ ˈgɒʔ ˈt^{h}̤ u ˈfʊi ˈʧɪʊdɹə˜n]	98.27%

Following the detailed study of Harry's speech output and intelligibility, the research questions were considered in relationship to the findings. The discussion is focused mainly on findings from T1 unless otherwise indicated, apart from section 5.26.6.

5.26 Discussion

The aim of this chapter has been to give a detailed description and analysis of Harry's speech, and to consider the impact of his speech production difficulties on his intelligibility as judged by a group of adult listeners. At T1 at the age of 7;5 years Harry's PCC was 62.11% and on the Picture Naming Task (Stackhouse et al., 2007) he produced only 21/60 whole words (35%) in adult-like forms, z=-8.44, so on both of these quantitative measures his speech was demonstrably below the level expected by a typical seven-year-old. His difficulties could be described as severe and, given that he had had several years of intervention, resistant to change. He could therefore be confidently included in that group of children described as having "persisting speech difficulties" (Pascoe et al., 2006).

5.26.1 What will the detailed perceptual phonetic analysis of Harry's speech at word level reveal in terms of a traditional phonological process analysis (PPA)? What features are not captured through a traditional PPA?

5.26.1.1 Phonological process analysis

The examination of Harry's speech first focused on a phonological process analysis, an approach designed to describe children's speech in terms of "patterns of error" (Miccio & Scarpino, 2008, p. 414). This current analysis included information from both SW and MWU, thus drawing on wider samples of data than those derived from the single word naming tests routinely used in clinical practice.

5.26.1.1.1 Structural analysis

The main structural pattern was that of cluster reduction. By the age of 7;5, as Harry was at T1, typically developing children use consonant clusters correctly over 90% of the time and the non-adult realisations that they produce are immaturities, primarily gliding of /r/

or an interdental or lateral realisation of /s/ (McLeod & Arciuli, 2009). They do not reduce clusters to a single element. Harry's pattern of cluster production in single words showed that he realised a third of them in the adult form, a third in an immature form (principally with a glided /r/ as the second element) and a third reduced to a single segment. His pattern was thus both delayed and atypical. In the context of multi-word speech even more clusters (over 40%) were realised as a single element, suggesting that that the complexity of the phonetic and phonological environment influenced his production, a theme which applied throughout the analysis of Harry's speech. Underpinning these patterns were difficulties in both input and output processing (see section 5.26.4). Although there was considerable variability in Harry's cluster production, the percentage of clusters realised in the adult form suggested that there were positive indications of change. The occasional instances of epenthesis, involving the insertion of a vowel between the two elements of the cluster, also represented a more mature form than those realised as a single element (McLeod, Van Doorn, & Reed, 1997).

5.26.1.1.2 Systemic analysis

Although intelligibility is most likely to be affected by structural processes (Klein & Flint, 2006), the presence of many systemic processes in Harry's speech (with a PCC of 62.11%) must also be considered as relevant to his intelligibility through the reduction of contrastiveness that results from multiple systemic errors. Monsen (1983) sets out the view that a PCC under 60% renders speech unintelligible and Harry's PCC was only just over that level. Harry's PCC was based on single word analysis (as described in Chapter Three, Methods) and in multi-word utterances systemic processes occurred more frequently so had greater impact on segmental realisation. The example of velar plosive fronting illustrated this with a quarter of SIWI targets in single words affected by fronting but over a third of those in conversational speech realised in this way. In the SFWF position, velars in single words were always realised with the target place of articulation but in conversational speech nearly half were realised as a glottal stop. Not only was velar fronting more common in conversational speech, but realisations were more variable which might have impacted on the ability of listeners to predict patterns and thus how much they recognised of Harry's speech.

The presence of several systemic processes also increased the risk of cumulative effects on whole word integrity, and this was exacerbated by variability. Note the realisations of

CRUST and TOUGH and 'COS in the example below, affected variously by cluster reduction, velar fronting and realisation of a labiodental fricative as an alveolar. Context supports the intelligibility of the utterance but examination of each word in isolation reveals potential uncertainty about the target and for loss of contrast.

Harry	I like the <u>crust</u> of the bread
	[ʔaɪ ˈlaɪʔ ðə ˈt̤ʰ ʌ_st ɒz͡. ə ˈbw̰ɛt]
J	Do you?
	Yeh, I like to rip it open
Harry	[ˈjɛ~~~~~~~~~ ʔaɪ ˈlaɪʔ d̩ə ˈwɪb ɪʔ ˈʔəʊʔp̚ ə˜n]
J	You like the crusty bits?
	<u>Cos</u> the <u>crust</u> is actually very hard to eat isn't it? (It's) so hard and <u>tough</u>
Harry	[tʰ əs ə ˈtwʌs ɪs ˈæsli vei ˈhɑd̩ t̚ u ˈit ɪdn̩ ɪʔ͡ səʊ ˈhɑd ən ˈtʰ ʌ̤s]

5.26.1.2 Features not captured through phonological process analysis

Many of the aspects of Harry's speech that were not captured through the phonological process analysis relate to his speech in multi-word utterances (see section 5.26.2) and variability (see section 5.26.3). However, one unusual factor was the presence of lexical "idiosyncrasies" or "frozen" forms (Bryan & Howard, 1992). These were consistently realised, usually multisyllabic words, for example MEDIUM realised as [ˈmĭdəmə˜n]; EVENTUALLY realised as [əˈbɛ˜ntəli]. It was likely that these words were learned at an earlier stage of speech development and these early established motor programmes had not been updated through any subsequent learning of more mature patterns. This may be related to difficulties with the perception of speech, perceiving segmental sequences in complex words or to difficulties with motor planning and execution (Stackhouse & Wells, 1997), assuming feedback and interactions between different levels of speech processing which support the development of a mature system. Some support for this hypothesis may come from Harry's difficulty in phonological awareness tasks requiring segmentation beyond simply onset and rhyme, as well as his already discussed difficulties in input and output skills in relation to complex phonology.

5.26.2 What does comparison of the patterns in Harry's speech data reveal across three speech elicitation conditions (1: single word production; 2 connected speech in sentence imitation; 3: connected speech in spontaneous conversation)

There were differences in Harry's speech output across the three sampling conditions. As described in section 5.10.1, for example, consonant clusters were used more frequently in single words than in conversational speech. Greater accuracy in single word naming than in conversation is a common (Faircloth & Faircloth, 1970; Klintö et al., 2011) but not unequivocal (Wolk & Meisler, 1998) finding in the literature. The explanation for this observation may be related to the higher demands of output planning across an utterance in comparison to a single word, particularly at a stage in development when more mature phonological and phonetic patterns are first used. Change in sound production is gradual (Barlow, 2001) and the use of newly established segments or sequences initially requires a level of focus and awareness on the part of the child. This attention to speech may be harder to maintain in the context of the processing demands of multi-word output and before recently learned patterns have become more automatic. Differences in performance in different sampling conditions, or even with the same items on different occasions may be a "consequence of an interaction between levels" (Crystal, 1987, p. 12); this may be particularly evident in children who have immature or disordered processing systems. Furthermore, in a usage-based model, exemplars which are longer established might be more automatically accessed if the child needs to manage greater processing demands.

Harry's difficulty in managing complex phonetic sequences was exposed in the sentence imitation task where on occasion, as described in section 5.11.2, his production of target words showed evidence of difficulties with motor planning. The long domain interactions between syllables and segments revealed by repetition of sentences would clearly not occur in single word naming. These atypical productions might have been a product of the task itself because sentence imitation requires the repetition of particular grammatical structures and vocabulary. In conversational speech children may be able to avoid items which they find difficult (Seeff-Gabriel, Chiat, & Dodd, 2010). However, given that Harry's expressive language skills had been assessed as in the typical range for his age, the grammatical structures and lexical items used in the assessment would be within the scope of his linguistic capacity. Therefore, it can be concluded that the imitation task revealed the vulnerability of aspects of Harry's phonological and phonetic processing skills, and interactions between these and imposed syntactic or semantic demands. The value of assessing his performance on the task, aside from its actual purpose in examining word juncture behaviours, was in providing several examples of these particular difficulties within a single set of stimulus materials which were recorded and analysed. Having identified these within the framework of the task, occasional occurrences in conversational speech could then recognised as further instances of the same types of difficulty. This contributed to the overall psycholinguistic conceptualisation of Harry's speech difficulties and in providing an explanation for his poor intelligibility where interactions between inaccurate phonological assembly and segmental constraints made stretches of his speech unrecognisable.

The inclusion of the different types of sampling conditions therefore, revealed phonetic, phonological and prosodic information which was not evident from the SW data alone. The analysis of conversational speech so far had suggested that, in addition to segmental difficulties, there was evidence that Harry's utterances were often characterised by unusual word and phrase harmonies and repetitions and repairs. Analysis showed many instances of atypical word juncture behaviours, affecting both the segmental accuracy and the structural integrity of word and phrase production. Inappropriate use of open juncture was evidenced by frequent use of pauses and glottal stops within phrases, and inappropriate close juncture was manifested by hyperelision, which reduced segment and syllables in an atypical manner. The particularly pervasive presence of elision and structural processes (final consonant deletion, syllable deletion, cluster reduction) in Harry's conversational speech compounded his intelligibility problems by significantly reducing the amount of information available to the listener for the purposes of lexical identification, supporting previous observations in the literature that structural simplifications are more damaging to intelligibility than systemic constraints (Faircloth & Faircloth, 1975; Klein & Flint, 2006).

Instances of hyperelision and hyperarticulation throughout the conversational speech data point to Harry's difficulties in balancing the competing demands of paradigmatic/articulatory accuracy and syntagmatic/prosodic fluency (Wells, 1994) in a conversational context. Harry's segmental phonological development was, in some ways, reminiscent of a much younger child, yet his control of prosodic features such as rate, volume, rhythm, and intonation patterns was, in his hyperelided speech at least, indicative of much more adult-like control. One further point about Harry's data was that they also supported the notion that in the process of speech development children learn and store not only words, but also larger constructions (Stoel-Gammon & Sosa, 2007) and that frequently-used, familiar constructions are likely to be subject to greater phonetic and phonological reductions than those which are less frequently used or encountered by the child (Bybee, 2006, 2010). These high-frequency utterances in Harry's speech were typically extremely reduced. Given his difficulties in input as well as output processing, it was possible that his phonological representations for these whole phrases were also underspecified.

The constructs of hyperelision and hyperarticulation may be valuable in interpreting children's data. However, as Howard, Wells and Local (2008, p. 595) propose "[to] suggest that individual children with multi-word speech difficulties may be categorised as 'hypereliders' or 'hyperarticulators' is an oversimplification", because children's speech output varies within as well as across different social and situational contexts. In this regard it is interesting to note that some of the differences between Harry's output in single words and multi-word utterances was reminiscent of the much younger child described by Peters (1977), who used an analytic speech style in picture-naming tasks and a more gestalt style in real conversation. Overall the preponderance of hyperelision in Harry's conversational speech corresponds to Peters' description of gestalt style and its articulatory and prosodic features combine to detract from intelligibility. In this Harry also resembles one of the participants described by Howard, (2013) in her study of persisting speech difficulties in two children with cleft palate speech. Some of Harry's prosodic behaviours and some of his word juncture behaviours in conversational speech were consistent with the "massive conversational reduction" in adult speech described by Johnson (2004), which is typical of real conversation and interaction: as such, this could be seen as a real strength of his speech production. However, because his segmental phonological system was significantly reduced for a child of his age, for the purposes of intelligibility "massive conversational reduction" is counter-productive for Harry. In other words, from the listener's perspective, if some sounds are going to be elided, it may be particularly important how those sounds which remain are realised. Johnson (2004) suggests that particular lexical items retain key individual features whatever the degree of reduction; he gives the example of /t/ being retained in all variations of the word UNTIL. It may be that for children like Harry there is a complex interaction between phonological processes and reduction, so that target words do not always contain the key features retained in typically reduced conversational speech production. In Harry's realisation of SHALL I TELL YOU WHAT?, [ən ˈdæd̪eːɪ ˈwɒʔh], there was significant elision, but it could be argued that the stopping of the /ʃ/ (which is also one of the segments which is "practically invulnerable" in reduced speech, Shockey, 2003, p.15) critically affected lexical identification and the intelligibility of the whole utterance.

Harry's speech in the sentence imitation task also showed the atypical word juncture behaviours seen in his conversational speech, which similarly affected both segmental accuracy and the structural integrity of his repetition. However, in contrast with conversational speech, hyperelision was not a feature of his speech production in this activity. This is probably not surprising given the formal and unnatural character of the interaction, and the fact that in a repetition task there is no opportunity to reformulate, rephrase, or avoid particular structures or items of vocabulary; nor can the speaker choose familiar or frequently-occurring words or constructions (Bannard & Matthews, 2008). It appeared that Harry sometimes struggled to manage the complex phonological and syntactic processing requirements of the task, and as already discussed, this led to errors in production which spread across the entire targeted utterance. There were echoes of this observed in hesitation and occasional reformulations in his spontaneous speech, suggesting again that it was sometimes an effort for Harry to manage the multiple levels of processing required for complex utterances.

5.26.3 Does Harry's speech output show phonetic variability within different speech elicitation conditions?

Harry did show phonetic variability in his speech output; this was related to several factors and was not always of the progressive type (Tyler & Lewis, 2005) where forms would switch between immature and adult productions. This type of inconsistency did happen on some occasions, particularly when comparing segmental patterns in a word produced on its own and in a multi-word utterance. However, there was no evidence that Harry was self monitoring or attempting to improve the accuracy of his realisations in any consistently productive way. There were times when variability was related to the complexity of the linguistic demands (Tyler, Williams, & Lewis, 2006); this was evidenced in Harry's performance in the imitated sentences task where given no choice in structure, vocabulary or speech demands, his output was subject to breakdown on several occasions. There were also instances of long domain consonant harmony which is indicative of a process of the simplification of articulatory gestures across an utterance. This leads to contextual variability where a word may be vulnerable to change as a result of phonological or phonetic constraints.

If Harry's variability was a reflection of the overall immaturity of his speech processing system (Rvachew, Chiang, & Evans, 2007) it may be more particularly related to his difficulties with the perception of complex sound sequences. Although at T1 these were more evident with non-words than real words, this may have had a more pervasive effect on his speech perception at an earlier stage of development. His variable productions may be linked to underlying phonological representations that were underspecified or "fuzzy" (Forrest et al., 2000; Stackhouse & Wells, 1997), impacting on the specificity of the motor programmes for output. Alternatively, variability may have been symptomatic of motor planning or motor execution difficulties where accurate motor programmes were established but the realisation of these was affected by immaturities or deficits in peripheral levels of output processing.

An interesting and unpredicted finding in the data was the pattern of ejective realisations of word-final plosives which at first appeared to be not only variable but rather random. On closer inspection, however, ejectives were shown to be distributed across the single word and multi-word speech data in a way which suggested that Harry was using such realisations as a turn-taking device to signal points of possible turn completion in his interaction with the clinician (Sacks et al., 1974). It is interesting to reflect that for all its unnaturalness compared with spontaneous, conversational speech, a picture-naming task, as negotiated between clinician and child, is nevertheless an example of interaction. This may be of a very specific kind but as such it might be reasonable to expect the interactional work being done to be marked by particular phonetic features (Drew & Heritage, 1992). This might be an important issue for clinicians to consider in assessment; features noted in single word naming tasks may over- or under-represent particular speech behaviours. Again it underlines the need for the analysis of different types of utterance to truly describe and explain complex speech patterns (Howard, 2004b; Klein & Lui-Shea, 2009).

5.26.4 Does the psycholinguistic speech processing profile provide explanations of Harry's speech output patterns?

Harry's speech processing profile shows that he had difficulties both in input and output skills. In input, discrimination of speech sounds in complex sequences was poor, for instance his impaired ability to identify the difference between the minimal pairs "grass/glass" and "crown/clown" at sentence level and his difficulty in the discrimination of similarities and differences in pairs of complex non-words. In comparison, recognition of production errors in even complex multi-syllabic single words when spoken by another person was accurate. In output Harry had difficulties at every level of the profile.

Perception of speech input forms the basis of establishing phonological representations which in turn provide a basis not only for word recognition but also for building motor programmes for speech output (Rvachew & Brosseau-Lapre, 2012; Stackhouse & Wells, 1997). However, it is too simplistic to assume simple linear relationships in processing skills for children like Harry who have persisting and complex speech difficulties. Whatever the "cause" of Harry's atypical output patterns, by the age of 7;5 he had developed a variety of skills and compensatory strategies. The speech processing profile thus captured a snapshot of his abilities at T1 rather than one which would necessarily provide an explanation for his difficulties. However, it did have value for the purposes of describing his processing skills and for intervention planning.

The literature shows that some children who have speech difficulties also have significant difficulty with speech perception tasks (Hesketh, Adams, Nightingale, & Hall, 2000; Rvachew, Rafaat, & Martin, 1999; Rvachew, 2012) which impact on speech production and phonological awareness skills. Harry's performance with input activities, which informed the profile, indicated that he would fit into the group of children who have poor perception skills. His recognition of errors in pronunciation showed that he had developed phonological representations that were sufficiently accurate for lexical recognition. However, his difficulties in perception suggested that he was not always able to make judgements of finely graded phonetic contrasts; this would then impact on the establishment of good quality motor programmes for the production of words. Real word discrimination in the context of single words was a relative strength suggesting that his performance on phonological tasks was aided by top-down processing. However, this was not necessarily the case at sentence level. The task design is such that the sentences did not aid discrimination by providing contextually biased cues (for example, "the boy's MOUSE was full of food" vs. "the boy's MOUTH was full of food") and the target words may have less perceptual salience in the environment of the sentence; Harry's responses on these items were at chance level. However, not all segmental contrasts were equally affected. For example, words containing alveolar and velar plosives in both SIWI and SFWF positions were identified with no errors at all in spite of the fact that Harry's output of these targets was variable. This indicated that perceptual vulnerabilities were not universal and that there was not a simple, linear relationship between input perception and output patterns (Lof, 1996; Rvachew et al., 1999).

Harry had significant difficulties in the discrimination of similarities and differences in pairs of non-words, even when these were CVC. This was particularly so with longer words as was assessed in the task requiring discrimination of segmental differences between pairs of complex non-words. It appeared that phonetically complex contexts presented him with particular challenges and that this also had implications for the updating of already established representations and motor programmes. In early development typical children may have "frozen" forms, usually high-frequency words or phrases which are stored and accessed as whole units (Locke, 1997). However, as the child's perceptual and motor skills develop, and lexical knowledge expands, these previously unanalysed units are updated to reflect the child's increasing proficiency in producing adult models. Harry's speech did show evidence of frozen forms (or "relics" Grunwell, 1992, p. 118) and indeed this was still the case at T2. The process of updating representations depends on effective interactions between levels of input processing (perceptual skills) and output processing (motor programming and programmes) (Rees, 2001). The diffuse deficits shown by Harry's profile suggests that it can be hypothesised that, as well as having difficulties within discrete levels of processing, interactions between levels are likely to be impaired (Chiat & Hunt, 1993). If this is indeed the case, the presence of frozen forms, symptomatic of an inefficient speech processing system, is unsurprising.

Harry's difficulties in the perception of segments in complex non-words, and SFWF contrasts in CVC/CVCC words had implications for his learning of new vocabulary, particularly lexical items that had complex sound structures and/or abstract meaning. He would be less likely to perceive finely graded phonetic details and more opaque semantic features might mean that he needed more exposure to individual words in order to establish stored representations.

Harry also had output difficulties at every level of the profile and there were no differences in the segmental patterns used between his naming and repetition of real words and of non-words. This indicated that the same constraints were affecting his output in each of these types of stimuli. He had oro-motor and motor planning difficulties as evidenced by his inability to elevate his tongue tip to command or visual model and his poor performance on the DDK task. While these impaired motor skills will have impact on his speech output, given Harry's input processing difficulties it is unlikely that motor difficulties alone could explain the severity and persistence of his disordered speech. However, there may be interactions between motor deficits and the development of, for example, speech perception skills (Galantucci, Fowler, & Turvey, 2006; Liberman & Mattingly, 1985). With so many areas of difficulty Harry's profile demonstrates the complex nature of interactions between levels of processing which can give indications of cause but not a definitive explanation of the nature of the speech output difficulty.

5.26.5 Does the intelligibility of Harry's speech vary across different speech elicitation conditions?

The quantitative scores for Harry's speech output suggested that his intelligibility would be compromised and this was reinforced by the findings of the structural and segmental phonological process analysis. Further to this, observation of the hyperelision in his speech in multi-word utterances, and indeed his own reflections on the difficulties that listeners had in understanding him, strengthened this prediction particularly in relation to MWU.

Harry's intelligibility, as measured through the perceptions of 66 adult listeners, showed that at T1 conversational speech was the least intelligible type of utterance (mean, 54.12%), followed by single words (mean, 59.78%) and that imitated sentences were the most intelligible (64.23%). The difference between conversation and single words was significant and Harry was the only one of the four study children to show this profile; the other children were all more intelligible in MWU than single words. The experience of Harry's listeners in identifying what he was saying matched the predictions based on assessment observations for conversation but not for imitated sentences. This was because the intelligibility of Harry's imitated sentences was aided by his frequent use of open juncture. It may have been that words in this type of sampling condition benefitted from the contextual support of a sentence but had clear word boundaries which aided recognition. It may be that children like Harry who are familiar with assessment situations are aware of the clinician's implicit expectations of "best speech" (Klintö et al., 2011, p. 355) and so use produce more careful speech characterised by conscious use of open juncture. However, the range of responses for all types of sample was very wide so not all listeners were aided in the same way even in imitated sentences.

5.26.6 Are any changes in Harry's speech output evident between two points in time and do any changes impact on the intelligibility of his speech?

In the 12 months between T1 and T2 Harry's speech improved so that his PCC was 79.5% (compared with 62.11% at T1) and his score on the Picture Naming Task showed the number of whole words correct was 32/60, z=-5.64 (compared with 21/60, z=-8.44, at T1). In spite of progress, Harry's speech difficulties were still significant. However, analysis of his speech output revealed that quantitative scores were reduced by developmentally later processes such as gliding, which do not impact on intelligibility in the same way as patterns such as cluster reduction and stopping (Weston & Shriberg, 1992). In addition, there were other positive indicators of change such as his improvement in non-word repetition.

Harry's input processing skills had improved and although he had some residual difficulties with consonant cluster discrimination in sentences, and his ability to manipulate speech sounds in words was poor, overall his ability to identify segmental patterns in complex words had matured. In terms of output processing skills, Harry's scores for imitation of both non-words and real words across all word lengths fell into the typical range (albeit that the ceiling for norms was set at a 7-year level). This would suggest that the perceptual and articulatory constraints that had lead to scores for real word naming and non-word repetition being very similar at T1 had lessened, and that Harry's poorer accuracy in naming reflected an ongoing difficulty or delay in updating established motor programmes (Bryan & Howard, 1992; Stackhouse & Wells, 1997). Another positive indicator was a reduction in variability (Forrest et al., 2000), at least at a single word level, although examples of idiosyncratic or unusual realisations of complex sound patterns in words also suggested the ongoing influence of underlying difficulties, perhaps related to the continuing deficits in Harry's motor planning/execution skills.

Harry's word juncture behaviours at T2 showed quantitative improvements in the structured sentence imitation task. However, in conversational speech the presence of hyperelision interacting with segmental differences and omissions rendered stretches of utterance unintelligible, even to the author who was by that stage very familiar with his speech patterns. Nevertheless, the overall improvement in PCC and the expansion of Harry's phonetic inventory to include, for example, the segments /ʃ/, /ʧ/ and /ʤ/ were on their own likely to have a positive impact on intelligibility (Yavas & Lamprecht, 1988).

Harry's intelligibility had improved with recognition of conversational speech showing a highly significant change. Unlike T1, at T2 Harry's conversational speech was the best understood type of utterance (mean, 82.17%), followed by single words (mean, 69.97%) with imitated sentences being least intelligible.

5.27 Summary and conclusions

A comprehensive phonological process analysis (PPA) of Harry's speech at T1 identified a range of processes, for example, cluster reduction and velar plosive fronting. However, further analysis beyond the scope of a typical PPA, particularly of MWU, revealed significant segmental and prosodic features which were not evident from a traditional single word naming test. This finding was similar to that revealed through the investigation of Tallulah's speech in that PPA was not sufficient to describe all the patterns which might impact on intelligibility. Like Tallulah his MWU showed frequent occurrences of open juncture although in Harry's speech glottal stops and pauses were observed more often at word boundaries. One characteristic of Harry's MWU was the presence of inappropriate close juncture manifested by hyperelision which significantly impacted on his intelligibility; this was not particularly evident in Tallulah's speech. Like Tallulah, Harry showed variability in speech output; at times this was progressive in nature but his output might also be affected by phonetic or linguistic context.

Psycholinguistic assessment indicated that Harry's speech processing skills showed impairments in both input and output tasks, therefore showing more pervasive difficulties than Tallulah, whose input skills were in the typical range. With input tasks Harry experienced more difficulty in activities involving non-words than real words, particularly those with complex segmental and syllabic structures. His speech patterns in output were similar in non-word repetition and picture naming suggesting that the same constraints affected all types of speech output. Harry's performance on a DDK task indicated that he had difficulties in motor planning and there was some evidence of poor power and precision in oro-motor movements. Tallulah did not demonstrate difficulties with non-word repetition and oro-motor skills, again indicating that Harry had more widespread impairments than she did. They both had difficulties with real word output and motor planning.

Harry presented with severe and persisting speech difficulties at T1 which affected the intelligibility of his speech in all types of utterance although listeners were better able to identify words as single items rather than those in MWU. The profile of listener responses was different to that of Tallulah where MWU were more intelligible than SW.

By T2, Harry's speech output and his intelligibility had significantly improved although he continued to show residual difficulties reflecting those identified at T1. In these respects he is similar to Tallulah.

The next case study in Chapter Six is Lily who was 7;2 at the time of the first assessment.

Chapter Six

Case Study: Lily

6.1 Background

At the beginning of the study Lily was 7;2; she was a girl who had a history of severe speech difficulties, first referred to speech and language therapy by the health visitor at the age of 3;1 because her speech "was slow to develop". There was a paternal family history of dyslexia but no other reported risk factors. Her hearing always tested as normal. Over the next four years, there were periods of intervention which focused on her production of speech sounds and the development of phonological awareness skills, but her progress was slow. Her early intervention was group-based and clinical records suggest that she was diagnosed with a phonological delay, which was expected to resolve. She was referred to the study because of concerns about her rate of progress and her poor intelligibility.

6.2 Initial observations T1 (C.A. 7;2)

In the first assessment session Lily was very quickly at ease, and throughout the study was a calm cheerful and hard-working child who was focused and organised in her approach to activities. She presented with good verbal comprehension, confirmed 5 months later through formal assessment, although her expressive language scores showed some significant difficulties with grammar and sentence formulation tasks (see appendix 6.1). Lily's effective interpersonal skills and social understanding were a positive counterbalance to her significant intelligibility difficulties. She had syntactic immaturities, for example, in tense marking where she over-generalised the regular past tense morpheme '-ed' ("we putted it on the tree"); she had word finding difficulties with, at times, slow recall of even familiar lexical items and occasional semantic errors.

The initial impressionistic assessment of Lily's speech was that that her intelligibility was poor and her voice quality was rather hoarse and breathy. Her intelligibility was affected by segmental and structural phonological processes particularly cluster reduction, velar plosive and nasal fronting and voicing of voiceless segments. Frequent use of glottal stops in all word positions was noted. In addition, there was evidence of timing issues, sometimes with slow transitions between or within words or effortful production of segments, especially fricatives.

6.3 Initial assessment T1

Lily's input processing skills and speech output skills in single words and multi-word utterances were assessed following the approach described in Chapter Three, Methods (see appendix 6.2 for her speech processing profile and 6.3 for the mapping of this profile to the speech processing model).

6.4 Input processing skills T1

The investigation of Lily's input processing skills included assessment tasks from Stackhouse, Vance, Pascoe and Wells (2007) and other non-standardised activities)..

- Discrimination between same/different SFWF single features and s-cluster sequences in real words and non-words for example, lot/loss; vot/vos; lots/lost; vots/vost, (Stackhouse et al., 2007). Lily's overall number of responses correct was 30/36 compared with a mean score of 35.25/36 (S.D. 0.79) for a typical 7-year-old. Her z score was -6.64, indicating a severe level of difficulty. There was no significant difference between the discrimination of single sounds (z=-4.91) and clusters (z=-4.33), but there was a difference between real words (16/18, z=-2.2), and non-words (14/18, z=-7.72), although both scores were significantly below the expected level.

- Discrimination of segmental differences between pairs of complex non-words (for example, same or different, /spəʊb/ vs. /spəʊd/; /ʧʌsp/ vs. /ʧʌps/, (Stackhouse et al., 2007). Lily's score was 75%, compared with a score of 90.66% (S.D. 7.5%) for a typical 7-year-old, z=-2.08. There was a marked discrepancy between Lily's score for recognising difference, which was 88.46% (compared with a norm of 87.95%, S.D. 10.96%), z=0.073, and her score for recognising similarity which was 50% (compared with a norm of 96.92%, S.D. 4.7%), z=-9.98. Examination of the pattern of errors in the task stimuli suggests that these results may have been related to either fatigue or poor attention (although neither was obvious from her demeanour). There are four blocks of test items but difficulty is not progressive. Lily scored 10/10 for block A, 7/10 for blocks B and C and 6/10 for block D, identifying all 3 "same" items correctly in block A, 2 in block B and only 1 in blocks C and D. The design of the test meant that items were more often different than the same. Lily may have realised this; if the task was difficult for her, it may have simply been easier to respond in the same manner to all items. Whatever the reason, it brought into question the reliability of her scores for discrimination of differences between complex non-words.

- Auditory lexical discrimination, (ALD) with pictures (Stackhouse et al., 2007), recognising production errors in 1, 2 and 3/4 syllable words. Lily's overall score across all word lengths was 113/120, compared with a mean of 114.7, (S.D. 3.17), z=-0.53 which was in the typical range for her age. Examination of different word lengths revealed some small differences. Her judgement of 1 and 2 syllable words was typical for her age (z=2.93 and -0.71 respectively) but her score for 3/4 syllable words was 35/40 compared with mean 37.65, (S.D. 1.52) z=-1.74. She accepted: /ˈhɒstɪpl̩/ for "hospital" (metathesis); /ˈpærəsut/ for "parachute" (place of articulation); /ˈbʌtəfaɪ/ for "butterfly" (cluster reduction); /pəˈʤɑbəz/ for "pyjamas" (manner of articulation); and rejected "hairdresser" as a real word. The errors relating to place of articulation, cluster reduction and voicing reflected production patterns evident in Lily's own speech production.

A number of phonological awareness activities were completed using the Hatcher, (1994) Test of Phonological Awareness and other non-standardised tasks (these tasks typically tapped both input and output skills). On the Hatcher assessment she scored 17/36 across all 6 subtests; the test does not give details of norms but is presented as suitable for children at the early stages of literacy development as Lily was. Results suggested that Lily's phonological awareness was beginning to develop but her skills were still immature. She was able to listen to words segmented into syllables (for example, "win-dow") or phonemes (for example, "r-ai-n") and identify those words, indicating that phonological representations for the words tested were accurate. She was able to sort pictures of CVC words by onset segment as long as the target sounds were ones she realised accurately, otherwise her own speech output in rehearsal interfered with the task. For example, she was not reliably able to sort between alveolar and velar plosive onsets. Given a choice of three words, Lily was able to identify the two which rhymed (4/6) but this was very slow. Her responses to these segmentation and rhyming tasks suggested that she had some awareness of the internal structure of phonological representations, in that she was able to manipulate phonological information without being entirely reliant on an adult model, but these skills were not yet secure.

Overall, Lily's task performance showed that she had some difficulties with input processing; mild difficulties in carrying out discrimination and judgement tasks with real words, more so if they were multisyllabic. However, she found tasks involving non-words more difficult, particularly when they had complex segmental and syllabic sequences. These findings implied that her perceptual skills were better when associated with meaning, i.e. a stored phonological representation. Such difficulties could impact on lexical development, particularly of more abstract words, because poor discrimination of the sound patterns of novel words would lead to difficulty in establishing clearly defined phonological representations (Chiat & Hunt, 1993).

6.5 Speech output skills T1

Lily's speech output skills were assessed using a range of single word tests; the Picture Naming Task (Stackhouse et al., 2007), the Non-Word Repetition Task (Stackhouse et al., 2007) and the Real Word Repetition Task (Stackhouse et al., 2007). She also completed subtests of the DEAP (Dodd et al., 2002). The single word (SW) analysis was based on 109 items collected during these tasks (appendix 6.4). The multi-word data are from the analysis of T1 conversational speech (CS) samples 1-7 (appendix 6.5 to 6.10) and selected imitated sentences from the Connected Speech Processes (CSP) Repetition Task (Stackhouse et al., 2007), (appendix 6.11); there are occasional examples from other conversational speech, which are indicated in the text.

The Picture Naming Task (Stackhouse et al., 2007) allowed comparison of Lily's whole word production with the expected score for a child of her age (see table 6.1); scoring is based on the number of whole words that match the adult target. Her overall score across all word lengths was 7/60 (11.66%), z=-12.01, compared with a mean score for a 7-year-old of 54.2/60 (90.33%), S.D. 3.93, indicating a severe level of difficulty in comparison with a typically developing peer group. Her scores for 1 syllable (4/20, z=-12.33), 2 syllable (3/20, z=-12.07) and 3/4 syllable words (0/20, z=-7.27) were all at a similar level of difficulty. Whole words scored as correct were DUCK, CAT, BOOK, SNAKE, TOILET, MONEY and LADDER.

Lily completed the Non-word Repetition Task (Stackhouse et al., 2007), (see table 6.1). Her score across all word lengths was 10/60 (16.66%), compared with a mean score of 48.85 (S.D. 4.66) for typical 7-year-olds, z=-8.33 indicating a severe level of difficulty. Lily scored equally poorly across all word lengths as can be seen in table 6.1. The credited non-words were /dæk; sɔk; kɛt; bɔk; vɪn; ˈteɪlət; ˈmɛnə; ˈlɛdɪ; ˈtɒləfaɪn/. Six of these words matched correctly named real words, DUCK, CAT, BOOK, TOILET, MONEY and LADDER.

Table 6.1 Lily: Scores for Picture Naming and Non-word Repetition Tasks T1

	Picture Naming Task (real words)		**Non-word Repetition Task**	
Word structure	Norms age 7 years: mean (S.D.)	Lily's score (z-score)	Norms age 7 years: mean (S.D.)	Lily's score (z-score)
1 syllable (N=20)	18.8 (1.20)	4 (-12.33)	16.05 (1.88)	5 (-5.87)
2 syllable (N=20)	18.45 (1.28)	3 (-12.07)	16.95 (1.90)	3 (-7.34)
3 & 4 syllable words (N=20)	16.95 (2.33)	0 (-7.27)	15.80 (2.33)	1 (-6.35)
Total (N=60)	54.2 (3.93)	7 (-12.01)	48.85 (4.66)	10 (-8.33)

The Real Word Repetition Task (Stackhouse et al., 2007) was also completed; Lily's performance was similar to the naming and non-word repetition tasks with a score across all word lengths of 11/60 (18.33%), z=-14.05 compared with a mean of 53.3/60 (S.D. 3.01) for typical 7-year-olds. She scored 7/20, z=-14.12 for 1 syllable words, 3/20, z=-9.62 for 2 syllable words and 1/20, z=-15.12 for 3/4 syllable words. Some accurate words were the same as those produced in the naming task i.e. DUCK, CAT, BOOK, SNAKE, TOILET, MONEY and, LADDER but in addition she realised LEAF, SOCK, VAN and TELEPHONE accurately too.

In summary, Lily's performance across all three tasks, naming and both real word and non-word repetition was equally poor. Stackhouse and Wells (1997, p. 47) suggest that this may reflect "generalized articulatory difficulties". However, it might be the case, also as suggested by Stackhouse and Wells (1997), that her performance reflected multi-level "pervasive phonological processing difficulties" (p. 47).

Non-standardised phonological awareness tasks showed that Lily could segment words into syllables by tapping or clapping although, when the task was first introduced, she needed adult help in the form of extra modelling and discussion. This was unexpected since her case notes suggested familiarity and success with similar tasks. She was not easily able to generate rhymes or reliably count the number of consonants and vowels in high frequency single syllable CVC words, although this was not aided by interference from her own impaired speech production. Lily's performance on these tasks indicated that she was not able to manipulate segments and simple words in output activities without adult help, and her skills were not at the level typically expected by the age of seven.

6.6 Oro-motor assessment and diadochokinesis (DDK) T1

Lily's oro-motor motor skills were assessed using items from the DEAP (Dodd et al., 2002). Her non-speech movements in isolation were accurate apart from tongue elevation which she was not able to perform to a model or verbal command. When asked to carry out a sequence of two oro-motor actions, her movements were affected by her lack of tongue elevation but her blow, kiss and cough were also lacking in force. Her performance on these tasks suggested that she had some difficulties with precision and power in non-speech oral movements. As described in Chapter Five, Harry, Williams and Stackhouse (2000) found that 70% of typical 5-year-olds were unable to elevate their tongue tip in an oro-motor task, and it may be that Lily's difficulties with tongue movements were a reflection of an immature motor system. However, this would not explain her general lack of oro-motor force.

Lily's DDK skills were assessed in a non-standardised way through repetition of a sequence of single segments [p], [t], [k] (see Methods, Chapter Three); she was able to produce all three segments in isolation. She was asked to do this 10 times after being given an adult model and three practise attempts. Lily was unable to produce the segmental sequence accurately at all so the real word "pat-a-cake" was tried as an alternative. Lily's realisation of the target was [ˈbæʔədeɪʔ] for seven attempts, [ˈbækədeɪʔ] for two and [ˈbæʔdeɪʔ] for one. Her attempts were perceptually slow and deliberate but did not have long pauses or hesitations. Lily's performance on the DDK task suggested that she had difficulties with motor planning (Stackhouse et al., 2007).

6.7 Phonetic inventory T1

Lily's phonetic inventory for consonants, based on single word and utterance level analysis is listed in table 6.2.

Lily's vowel inventory included all vowels expected for her accent of English (see Chapter Three, Methods). In this analysis the realisation of /t/ as a glottal stop in SFWW and SFWF positions and vocalisation of SFWF /l/ to [ʊ] (Grunwell, 1987) are judged as typical for Lily's accent.

Table 6.2 Lily: Phonetic inventory (consonants) in SW and CS T1

	Bilabial	Labiodental	Alveolar	Palatal	Velar	Glottal
Plosive	p b		t d		k g	ʔ
Ejective	p'		t'		k'	
Nasal	m		n		ŋ	
Fricative		f v	s			h
Affricate						
Approximant	w	ʋ	l	j		
Other						

6.8 Stimulability T1

Stimulability for English consonants was assessed using the DEAP items (Dodd et al., 2002). Lily was stimulable for /z/ in isolation following repeated modelling and several attempts at production but not for the other segments not in her inventory (i.e. /ʃ, ʒ, ʧ, ʤ, θ , ð, ɹ/. She had difficulty in imitation of both /g/ and /v/ in CV syllables and in isolation (in spite of them being used sometimes in speech). /g/ was realised as the voiceless cognate [k], and /v/ was also devoiced. Her efforts to imitate /ʤ/ resulted in [t] in CV syllables but repeated productions of [g] in single sound repetition. She was easily stimulable for the /s/ clusters /sn/, /sm/ and /sp/ but not for any other clusters.

6.9 PCC T1

Lily's SW PCC was 44.90% and her PVC was 92.06% giving a PPC of 68.48%. Scores were derived from 109 single words. This PCC score puts her speech into the Shriberg and Kwiatkowski (1982) category of severe difficulties for consonant production (less than 50% correct).

6.10 Phonological process analysis T1

A phonological process analysis was completed using data primarily from single words and conversational speech, supplemented by data from imitated sentences. There was evidence, both in SW and multi-word data, of both structural and systemic processes as well as word level assimilatory errors (see table 6.3). Structural processes included weak syllable deletion, final consonant deletion (although glottal stop realisation was a more common pattern), and cluster reduction. Systemic processes included glottal stop realisation of fricative segments, velar fronting, deaffrication, stopping and gliding. Lily's realisation of voiceless segments was variable in that they were frequently voiced, particularly in multi-word utterances.

Table 6.3 Lily: Phonological processes (consonants) T1

	Target (SW)	Lily's realisation	Target (conversational speech, CS)	Lily's realisation
Structural processes				
Cluster reduction	CRAB	[dæb̥]	AND HIM LIKE TRACTORS AS WELL (CS 4, T1)	[æ̃n ɪ̃m ˈlaɪʔ ˈdæʔdəd ə ˈwɛ̤ʊ]
Weak syllable deletion	TOMATO	[ˈmɑ̃ʔəʊ̤]	MUSIC ON THE – COMPUTER (CS 2, T1)	[ˈmʊ̃dɪʔ ɒ̃n də (.) p' (.) ˈbuˈʔɑ̤]
Final consonant deletion	ROOF	[ʋu]	THEN MY STEPSISTER COME ROUND (CS 5, T1)	[dɛ̃n maɪ ˈdɛʔɪʔdə ˈɬʌ̆m ͡waʊ̃]
Systemic processes				
Glottal replacement	SAUSAGE	[ˈʔɒʔhɪdz̥]	SOMETIMES WE CALL IT TILLY, SOMETIMES WE CALL IT TINY (CS 1, T1)	[ˈʔʌ̰̃ndaɪ̃m wi ˈdɔl ɪʔ ˈdɪl̥i ˈʔʌ̰ndaɪ̃m wḭ ˈdɔl ɪʔ ˈda̰ɪ̃ni̤]
	PARACHUTE	[ˈpʰ æwəʔuʔ]	WE BOTH START FIGHTING (CS 6, T1)	[wi bəʊʔ ˈdɑʔ ˈfaɪʔɪn]
Velar fronting & glottal stops	GIRL	[dɛʊ]	AND WE CAN'T TAKE IT FOR A WALK YET (CS 1, T1)	[æ̃n ˈwi ˈdɑ̃nʔ ˈdeɪʔ ɪʔ vɔ̆ʷ ə ˈwɔk̥ʔ ˈjɛ̤ʔ]
Deaffrication	JELLY	[ˈdɛli]	BUT THEN HIM NOT JUMPED UP (CS 5, T1)	[bʌʔ ˈnɛ̃nɪ̃nɒ̃ʔ ˈdʌ̃mpt ʌp̥]
Stopping	GLOVE	[dʌb̥ʰ]	A HIGH SCHOOL MUSICAL (?PILLOW) (CS 2, T1)	[ə ˈʔaɪʔ dʊ̆ʊ ˈmʊ̃dəʔʊ ˈbɪləʊ̤]
Gliding	RING	[wɪŋ]	AND A CAMERA (CS 2, T1)	[ɛ̃n ə ˈdæ̃mwə]
Voicing	CATERPILLAR	[ˈdæʔəp˭ ɪlə̤]	RED & PINK (CS 3, T1)	[ˈwɛd͡ ɛn ˈbɪ̃ŋk˺]
Word level assimilatory errors				
Consonant harmony	BIRTHDAY	[ˈbɜʔbeɪ].	IT KEEP ON NIPPING PEOPLE (CS 1 T1)	[ɪʔ ˈbiʔ ɒ̃n ˈnɪ̰ʔˈbɪ̃n ˈbiˈbə̤ʊ]

6.10.1 Structural processes T1

The most frequently occurring structural process across both SW and MWU was cluster reduction. Consonant harmony was also a feature of Lily's speech. Weak syllable deletion occurred in word initial unstressed syllables preceding a stressed syllable, but these were relatively few in number; final consonant deletion occurred, but infrequently and not with any predictable segmental pattern.

6.10.1 1 SIWI and SIWW clusters in single words and conversational speech

All SIWI consonant clusters were examined (see table 6.4); clusters in MWU were included in analysis only when the target was unambiguous. Lily, almost without exception, reduced SIWI/SIWW clusters to a single element. In the SW sample this process occurred in 93.33% (28 out of 30) of SIWI/SIWW clusters and in CS in 100% (17 out of 17) of clusters. In SW the two exceptions were [snɛ̃ɪk'] for SNAKE (which appeared to have been learned as an isolated lexical item in a recent intervention which focused on /s/ clusters), and [fwi] for THREE.

Table 6.4 Lily: Realisation of SIWI and SIWW consonant clusters in single words and conversational speech T1

Process	SW (30 items)	CS (17 items)	Examples
None (i.e. cluster realised accurately)	3.33% (1/30)	0% (0/17)	SNAKE [snɛ̃ɪk'] (SW)
Realised with 2 elements (immature)	3.33% (1/30)	0% (0/17)	THREE [fːwi] (SW)
Reduction to a single element	86.66% (26/30)	94.11% (16/17)	FROG [fːɒgᵊ] (SW); PLATE [b̤eɪ..ʔ] (SW); PLAYER [ˈbeɪjə..] (CS 2, T1); START [ˈdɑʔ] (CS 5, T1)
Coalescence	6.66% (2/30)	5.88% (1/17)	SWING [fːɪ̃ŋ] (SW); BUTTERFLY [ˈbʌʔəβaɪ] (CS 5, T1)

Clusters were reduced in different ways but the patterns were predictable and were the same in SW and conversational speech. Plosive plus approximant clusters were reduced to a single plosive segment, but fronted if the target was a velar, [dæb̥] for CRAB, [d̥ʌb̥ː˺tʰ] for GLOVE; /fl/ and /fr/ clusters were reduced to a single /f/ so, for example, FLOWER was realised as [ˈfːaʊ̤wə̤]. /s/ plus plosive clusters were generally reduced to a single plosive segment so that SPIDER was realised as [ˈbaɪd̥ə] and SCOOTER as [ˈduʔhʌ̤]. /s/ plus approximant appeared to follow slightly different patterns. /sw/ was realised with the coalescence of /s/ and /w/ so that SWING was [fːɪ˜ŋ]; /sl/ was realised as a glottal stop, for example, SLIPPER as [ˈʔɪʔpʰ ɑ̤]. Lily's realisation of /sl/ appears to involve two processes, firstly /sl/ was being realised in a similar way to other /l/ clusters where /l/ was deleted (as in FLOWER [ˈfːaʊ̤wə̤] and PLATE [b̤ɛɪ̤ʔ]); secondly the realisation of the SIWI [s] as a glottal stop. Grunwell (1987) suggests that there is no reason, other than for descriptive logic, to suppose any sequential application of processes where it appears that more than one is being used and that they could be "said to apply simultaneously rather than sequentially" (p. 187).

6.10.1.2 SFWF and SFWW clusters in single words and conversational speech

SFWF consonant clusters in the samples were examined (table 6.5). In the SW there were 6 examples of SFWF or SFWW clusters and 28 in the CS. The SFWF clusters sampled did not include the cluster /nd/ in the word AND because it was used frequently and realised in several different, but appropriate forms. For example, AND THEN realised as [ə˜n ˈnɛ˜n] (CS 6); AND WHITE AND BLUE realised as [æn ˈwaɪ̤ʔ æn ˈb̤ṳ] (CS 3). This type of reduction and variability occurs in typical adult speech (Shockey, 2003).

The examples in table 6.5 illustrate that the major issue in the realisation of SFWF clusters was that the fricative element of any cluster was stopped or omitted. Even on the one occasion from both samples that Lily produced a fricative, LEGS [lɛg̊ts̬] (SW), she preceded the target (which was devoiced) with a stop, resulting in an affricate realisation.

Table 6.5 Lily: Realisation of SFWF and SFWW consonant clusters in single words and conversational speech T1

Process	SW (6 items)	CS (27 items)	Examples
None (i.e. cluster realised accurately)	33.33% (2/6)	39.28% (11/28)	ROU<u>ND</u>ABOUT [ˈwəʊ̃ndə̆baʊ̃..ʔ] (SW); ELEPHA<u>NT</u> [ˈɛləfːə..̃nʔ] (SW); JUM<u>PED</u> [dʌ̃mpt] (CS 5, T1); CA<u>N'T</u> [dɑ̃nʔ] (CS 1, T1)
Reduction to a single element, including a glottal stop	33.33% (2/6)	39.28% (11/28)	ORA<u>NGE</u> [ˈɒwɪ̃nː] (SW) ; BISCUI<u>TS</u> [ˈbɪʔkɪ..ʔ] (SW); SOMETI<u>MES</u> [ˈʔʌ̰̃ndaɪ̃m] (CS 1, T1); TRIP<u>PED</u> [dɪʔt] (CS 5, T1)
Stopping	33.33% (2/6)	14.28 % (4/28)	GLO<u>VES</u> [dʌb̥tʰ] (SW); LU<u>NCH</u> [lʌ̃nt'] (CS 5, T1); NA<u>MES</u> [nɛ̃ɪ..md̥ː] (CS 1, T1)
Final consonant deletion	0% (0/6)	7.14 % (2/28)	ROU<u>ND</u> [waʊ̃]* (CS 5, T1

*Note nasalisation of the vowel suggesting the preservation of the nasality feature of the deleted alveolar nasal adult target

6.10.2 Systemic processes T1

The most frequently occurring systemic processes in Lily's speech were glottal replacement, velar fronting and voicing. Her realisation of vowels was also considered.

6.10.2.1 Glottal stop realisations

Lily's speech showed frequent use of glottal stops and some of these within-word and SFWF realisations of /t/ were associated with Lily's accent, for example, CA<u>T</u>ERPILLAR realised as [ˈdæʔəp̚ ɪlə..] and TOILE<u>T</u> as [ˈtɔɪləʔ]. However, other contexts were not explained by her regional accent, particularly (but not only) where glottal stops replaced alveolar and post-alveolar fricatives /s, z, ʃ/ and the glottal fricative /h/

(although this last pattern is not uncommon in Lily's linguistic community). This affected not only within-word and word-final segments but also word-initial fricative targets, for example, SAUSAGE [ʔɒʔˈhɪdz.ɹ̣]; HAIRDRESSER [ˈʔɛəd.ɛʔʌ̤]; SHEEP [ʔip']. However, there was some variation in what was perceived for SIWI targets and on occasion it appeared that the target was omitted rather than realised as a glottal stop. For examples, ZEBRA realised as [ˈɛbvə]. There were also instances of typical realisations of these targets, for example, were /s/ as [s] in SOCK and /h/ as [h] in HOUSE. In the SW data, 15 out of 19 possible productions of SIWI or SIWW /s/, /z/, /ʃ/ and /h/ targets were transcribed as glottal stops or deletions; in MWU all occurrences were realised as a glottal stop or deleted. Examples of SIWI glottal stops in MWU include, in conversation, WHEN WE SEE SHEEP HIM SAY [ˈwɛ̃n wi ˈʔi ˈʔip ɪ̃m ʔɛɪ] and in sentence imitation WE SAW AN ELEPHANT AT THE ZOO realised as [wi ˈʔɔd̚ də ˈʔɛləvə̃nʔ hɛ̤̆ də ˈʔu].

In SFWF positions glottal stops were common in both SW and MWU with similar patterns in all contexts. For example, in the conversational speech samples 95.45% (42/44) SFWF /t/ segments were realised as a glottal stop, which was typical for Lily's accent, but 27.77% (5/18) of SFWF fricatives were also produced in this way, which was not. SFWF consonant clusters where target segments were plosives or fricatives were also susceptible to this process.

In addition to the patterns of fricative realisation described, SIWI plosives and fricatives in word-initial unstressed syllables were also liable to glottal stop realisation, for example, PYJAMAS realised as [ʔəˈdɑ̃məʔs].

6.10.2.2 Velar fronting and glottal stops

The realisation of velar targets was influenced by their position in words and, to a lesser degree, the type of utterance i.e. SW or CS, within which they occurred (see table 6.6). For example, voiceless velar segments in SIWI positions were frequently fronted but in SFWF position, particularly in multi-word speech, were subject to glottal stop realisation.

In SW 7/15 (46.66%) of SIWI/SIWW and 7/9 (77.77%) of SFWF/SFWW velar plosives matched the adult target but in multi-word speech SIWI velars were usually fronted (29/31, 93.54%) and in SFWF position the voiceless target was usually realised as a glottal stop (14/16, 87.5%). The voiced velar plosive was realised accurately in coda position both in

SW and CS, although in the stimulability assessment Lily had been unable to produce this segment in isolation or in a CV syllable even with careful adult modelling. It is possible that that the realisation of SFWF /k/ as a glottal stop reflected Lily's usual realisation of the voiceless alveolar plosive /t/ i.e. /k/ was fronted and /t/ was realised as [ʔ].

Table 6.6 Lily: Fronting and glottal replacement of velar plosives in SW and CS T1

	Velar plosives fronted SIWI/SIWW	**Velar plosives realised as a glottal stop SIWW**	**Velar plosives fronted SFWF/SFWW**	**Velar plosives realised as a glottal stop SFWF/SFWW**
SW	46.66% (7/15)	6.66% (1/15)	11.11% (1/9)	11.11% (1/9)
CS	93.54% (29/31)	6.45% (2/31)	n/a	87.5% (14/16) /k/ only; /g/ always typically realised (3/3)

Another difference between single words and multi-word speech was the realisation of the velar nasal. In SW 40% (2/5) were fronted and realised as [n] but in MWU it was always fronted. Realisation of -ING with an alveolar nasal is a socio-phonetic variant in Lily's accent for example, FISHING realised as [ˈfɪhʔhɪ˜n].

6.10.2.3 Voicing

Lily's speech across all contexts was affected by inconsistent marking of the voiced-voiceless contrast in obstruent consonants, which was not necessarily context sensitive but was sometimes the result of consonant harmony. This may be illustrated through further examining velar plosive production, in this case in SIWI position in SW (see table 6.7). In this context Lily's realisation of voiced and voiceless segments was variable, even where the place and manner of articulation of the target segment was accurately produced; this was less so in MWU where voicing appeared to be the default.

Table 6.7 Lily: Voicing of SIWI velar targets in SW T1

Target word		**Lily's realisation**	**Voicing: accurate or not?**
CAR	/kɑ/	[kʰ ɑ̤]	Yes
CARAVAN	/ˈkærəvæn/	[ˈtʰ æwəwæ̤˜nt]	Yes
CAT	/kæt/	[kʰæt]	Yes
CATERPILLAR	/ˈkætəpɪlə/	[ˈdæʔəp˭ ɪlə̤]	No
CRAB	/kɹæb/	[dæb̥]	No
CROCODILE	/ˈkrɒkədaɪl/	[ˈdʌʔədaɪjəʊˌh]	No
GIRL	/gɜl/	[dɛʊ]	Yes

GLOVE	/glʌv/	[d̥ʌb̥ː˺tʰ]	Yes

In the examples given, 4 of the 8 segments were realised with accurate voicing (even if the velar was fronted) and 4 were not, so CAT was realised as [kʰ æt] but CATERPILLAR as [ˈdæʔəp˭ ɪlə̤].

The voicing differences in SW were not seen in MWU where Lily showed little variation in the realisation of voicing contrasts, resulting in long domain harmony across utterances that were voiced throughout, for example:

BUT I DID GET TWO AND I KEPT THEM (CS 6, T1)
[bʌʔ ai ˈdɪʔ dɛ̤ʔ ˈdu ə̃n ˈaɪ ˈdɛʔ ˈdɛ̃n̤]

DIDN'T GET OUT COS I PUT IT IN A TIN IN THE GARDEN WITH HOLES IN (CS 6, T1)
[ˈdɪdə dɛ̤ʔ əʊ̤ʔ dəd aɪ ˈbʊʔ ɪʔ ɪ̃n ə ˈdɪ̃n ɪ̃n ə ˈdɑdə̃n wɪd̪ ˈʔaʊl dɪ̃n]

There were several examples of the segment /p/ being realised accurately, as in HER HELP PEOPLE [ɛ ˈɛlp˺ ˈpʰ ipʰ əl]; however, PURPLE was realised as [ˈb̤ɜʔpʰ ə̤ʊ] in the utterance immediately before this one (CS 3, T1).

6.10.2.4 Deaffrication

Deaffrication had a less pervasive effect on Lily's speech than other processes but this may relate to the frequency with which opportunities for affricates occurred in the data. SIWI affricates only occurred 10 times throughout the SW and CS samples (see table 6.3). They were always deaffricated i.e. realised as a stop (Dinnsen et al., 2011), for example, CHAIR realised as [tʰ ɛə̤ː]. In SFWF position the adult targets were deaffricated in 40% (2/5) of instances, realised as a glottal stop in 20% of instances (1/5) and realised with immature affrication in 40% (2/5) of instances with /ʧ/ realised as [tːs̺] and /ʤ/ as [dz̺], for example, SAUSAGE [ˈʔɒʔhɪdz̺].

6.10.2.5 Gliding

Immaturity was also evident in Lily's realisation of the post-alveolar approximant /r/ which was usually glided to [w] when it occurred as a single segment but omitted when in a cluster. For example, RING was realised as [wɪŋ]; CRAB as [dæb̥]. There were occasional instances of the labiodental approximant being realised as in ROOF [ʋu].

6.10.2.6 Stopping

Stopping was an infrequently seen process for Lily but this may be partly because alveolar and post-alveolar fricatives (segments which may be liable to stop realisation) were also subject to ICD and glottal replacement. There were a few examples in SW and conversational speech, enough to suggest that stopping was a process affecting production in word-final positions at least. In CS samples she realised IT WAS as [ɪʔ wəd̚] and in sentence imitation GOOD GIRLS ARE NICE was realised as [ˈdʊ̤ʔ ˈdɛ̤ldɑ ˈnaɪ..ːt'] with stopping of both the plural /z/ and utterance final /s/.

6.10.2.7 Vowels

In single word naming Lily's PVC vowels was 94.68%; her vowel inventory was typical for her accent and non-adult forms were rare. Some realisations were affected by lengthening (see section 6.11.1) but the durational effects did not alter the categorical perception of the vowel. In conversational speech atypical vowels were also rare but there were occasional examples of what appear to be consonant-vowel interactions. For example, in the phrase AND THEN HIM TRIPPED OVER-OVER A LIGHT 'COS IT WAS- IT WAS –IT USED TO BE PIRATE DEN (CS 5) realised as [ə˜ˈnɛ˜nɪ˜n ˈdɪʔt ⁀əʊdə (.) ˈəʊvə ə ˈlaɪ..ʔ **dɪd ɪʔ** wəd̚ (.) ɪʔ wəd̚ (.) ɪʔ ˈjuʔ də bi ˈbaɪwəʔ ˈdɛ˜n] the first vowel in 'COS IT was the mid close [ɪ] rather than the more likely centralised neutral /ə/. It appeared that the alveolar plosive /d/ both in word-initial (fronted velar) and word-final (stopped fricative) positions led to harmonisation of production across the consonants and the vowel. Elsewhere, in CS 6 she used the more typical schwa, [dəd], in the phrase DIDN'T GET OUT COS I PUT IT IN A TIN [ˈdɪdə dɛ..ʔ əʊ..ʔ **dəd** aɪ ˈbʊʔ ɪʔ ɪ˜n ə ˈdɪ˜n]. The low incidence of these types of consonant–vowel interactions meant that their overall impact on intelligibility was also likely to be low. Production differences of this type may not be at all significant except in the context of the speech of a child with persisting difficulties where they may be yet another product of an immature system.

It was concluded that non-adult vowels, occurring in less than 6% of instances and all in unstressed syllables, were not frequent in naming or conversational speech. However, the interpretation of their occurrence as a product of an immature speech processing system was supported by Lily's output in the sentence imitation task where she had atypical realisation of several vowels not seen in naming or spontaneous speech. For example, /æ/

in WR<u>A</u>PPED was realised as [ɛ] in the phrase SHE (HER) WR<u>A</u>PPED THE PARCEL [ɜʔ ˈwɛʔ də̆ ˈbɑ̤ːhə̤l]; /ʌ/ was realised as [ɛ] in J<u>U</u>MPER in I WORE A J<u>U</u>MPER produced as [aɪ ˈvɔʷ ɪ ˈdɛ̃nʔbʌ̤]. In the sentence MY MUM HUGGED ME WHEN I WAS SAD the /ʌ/ in H<u>U</u>GGED was also realised as [ɛ], and /æ/ was realised as a diphthong in S<u>A</u>D, [ˈmaɪ ˈmʌ̃m̩ ˈɛʔ m̃ɪ wɛ̃n aɪ̆ wʊ̆t' ˈɑə̤t']. One further example was the realisation of /ɜ/ in the phrase MY LEFT LEG HURTS which was produced as the rhotic /ɝ/, [maɪ ˈlɛf ˈɬɛd' ˈɝʔ]. These unpredictable realisations may have been, at least in part, a product of the task. Lily's capacity to manage the constraints imposed by trying to exactly reproduce what she had heard had unplanned phonetic consequences because of the limitations of her speech processing system.

6.10.3 Word level assimilatory errors

Lily made some word level errors which could best be described as consonant harmony both in MWU and in SW.

6.10.3.1 Consonant harmony

There were several examples of consonant harmony in Lily's data and these most often occurred in MWU across strings of words rather than SW and some of these occurred in the sentence imitation task. For example, the sentence THE YELLOW AEROPLANE CRASHED was produced as [lə ˈlɛləʊ ʔɛləˈvẽɪn ˈdæ̤ʔ. t] with the SIWI (and utterance-initial) target /ð/ realised as [l], anticipating the /l/ in the immature [ˈlɛləʊ] and possibly the realisation of /r/ as /l/ in AEROPLANE. (Lily's habitual production of THE was [də] or [ə]). There were other instances where on first examination the harmonisation might be attributed to Lily's favoured voice, place and manner of articulation i.e. simply reflecting stopping, fronting or voicing processes. For example, JOHN COLLECTS STAMPS was produced as [ˈdɒ̃n dəˈdɛʔ ˈdæ̤̃nt]; the realisation of all SIWI segments could be explained by deaffrication, fronting of a velar plosive and cluster reduction respectively, with voicing as a default across the whole utterance. However, this would not explain the realisation of SIWW /l/ as [d] in COLLECTS or the final nasal cluster /mps/ as [nt] in STAMPS, especially when in other spontaneous situations Lily successfully used both SIWW /l/ in TILLY [ˈdɪli] (CS 1) and SFWF /mpt/ in JUMPED [ˈdʌ̃mpt] (CS 5). An explanation of consonant harmony with a unifying alveolar place of articulation, plosive manner and plus voice would appear more convincing.

In conversational speech there were also examples of long domain harmony. For example, in the utterance IT KEEP ON NIPPING PEOPLE the SIWI adult velar target in KEEP was realised as [b], [ɪʔ ˈbiʔ ɒ˜n̥ ˈnɪ˷ʔˈbɪn ˈbiˈbə̤ʊ], anticipating the bilabial plosives in the following words. Although the harmonisation was generally anticipatory, there were occasional examples of retrograde assimilation, for example, LIPSTICK was realised as [ˈlɪp.bɪʔ] and BIRTHDAY (CS 2) was realised as [ˈbɜʔbeɪ]. These particular examples could also be explained in the context of "frozen" forms (Bryan & Howard, 1992). These are early-established utterances that are unchanged over time by progressive development of the child's phonological system, and there were other occasional instances that show what appeared to be very immature forms occurring in Lily's speech (for example, THANKYOU realised as [ˈmːɛ˜nʔjuː].

6.10.4 Summary of phonological process analysis T1

The phonological process analysis revealed a significant number of processes impacting on the structure and segmental content of Lily's speech. Her realisations of adult targets were constrained by multiple structural and systemic processes which would impact on her intelligibility because of the cumulative effects on the realisations of individual words and multi-word utterances. However, a process analysis did not capture all of the speech patterns which might be important in providing a full description of Lily's speech production.

6.11 Features not captured through phonological process analysis T1

The assessment data revealed that there were other features of Lily's speech which could not be accounted for through a traditional phonological process analysis. These features were examined through further analysis which included exploration of Lily's management of transitions between segments, consonant and vowel durations, and word juncture behaviour in multi-word utterances. There was also a consideration of the variability in her speech and her voice quality.

6.11.1 Segmental transitions and duration

One of the striking features of Lily's speech was presence of atypical transitions between segments. These were identified through perceptual rather than instrumental analysis and took different forms, including perceptible lengthening of either consonants or vowels, for example, V̲AN realised as [fːæ̤˜n], FI̲V̲E realised as [faɪ̤ːp̬]. She also produced words which had consonant insertions, frequently but not only /h/, for example, FISHING realised as [ˈfɪhʔhɪ˜n]. The position of the segment i.e. SIWI, SIWW or SFWF was not predictive of the likelihood of longer duration. For example, in FOOT realised as [fːuʔ] it was the consonant to vowel onset of the word that was lengthened; in WATCH realised as [ʔv.͡wɒʔk'] both the onset and word-final consonant segments were realised in an atypical manner. Fricatives in all distributions were more vulnerable to lengthening than plosives or nasals. This may be because the fricative manner of articulation was a relatively recent development and she was less practised in the necessary coarticulation needed to realise these new motor programmes. Vowel segments were also particularly vulnerable to realisation with longer than typical duration, for example, JAM realised as [dæːn]; BIRD realised as [bɜːd̥]; MOON realised as [mu.˜iəːn], on occasion vowel realisations were both lengthened and subject to variability. It was also the case that Lily's voice quality was slightly hoarse and rather breathy, and this was particularly noticeable in lengthened vowels.

In addition to those types of productions already described, there were instances of atypical realisations related to the production of vowels in the unstressed CV syllable in a disyllabic word with a trochaic pattern. Here Lily did not realise the vowel segment as a schwa (as would be predicted in the adult target) but as a lowered, backed vowel which had a long duration for example, SLIPPER was realised as [ˈɪʔpɑ̤ː]; ZEBRA realised as [ˈɛbʋɑ̤ː]. Vowels with lengthened duration also occurred within words; it was possible that these might allow her extra transition time towards consonant segments, for example, HOUSE was realised as [haʊːptʰ], with extra duration on the second element of the diphthong. Another aspect of these unusual transitions was the presence of glottal stops accompanying target segments within words and word-finally. For example, LEAF realised as [liʔf̚] and SLIPPER realised as [ˈʔɪʔpʰ ɑ̤]. It is possible that these glottal stops, occurring in CVC words which had templates restricted to CVʔ or ʔVʔ syllables, were outputs based on motor programmes that had been subject to partial updating but still reflected previous constraints. Another interpretation is that these realisations were a consequence of intervention. For example, when producing SFWF labiodental fricatives (as in LEAF), which had been a target in intervention, Lily's articulatory placement of her top teeth on her bottom lip was over-exaggerated and slow. Her pattern of glottal replacement in SFWF position had not been eliminated and it appeared that the labiodental fricative was added to the existing motor programme rather than effectively updating it to reflect the adult target form. It may be that these atypical syllable-final glottal stops reflected a transitional phase in Lily's speech development.

The most unusual forms of lengthened duration occurred mainly in single words but there were occasional instances in utterance final positions in MWU. For example in sentence imitation Lily realised ALICE PUT GLOVES ON HER HANDS as [ɛˈlɪs̃ bɪʔ ˈdʌb ̃ɒ̃n ə ˈæ̃nːd̥]; the SFWF (and utterance final) consonant cluster showed lengthening of the /n/ before a stop and deletion of the SFWF fricative. The occurrence of these atypical forms in SW and at turn-end may reflect extra planning time afforded by open juncture in these two contexts. This enabled Lily to attempt more complex segmental sequences in the context of the rapid processing demands of continuous utterances.

6.11.2 Variability

In the SW data there were instances of token to token variability, where the same lexical item was realised differently at separate times during the assessment. Variable realisation was not frequent and occurred just 4 times in the sample. These were: SOCK realised as [sʲ ɒp] and [sɒʔ]; TIGER as [ˈtʰ ːaɪvə] and [ˈt̃ aɪdə]; THUMB as [fwʌ̃nt] and [fʌ̃mp]; WATCH as [wɒtːs̪] and [wɒtː']. Lily did not meet the 40% inconsistency on the DEAP subtest so did not meet Dodd's criterion for a diagnosis of Inconsistent Phonological Disorder (Dodd et al., 2002; Dodd, 1995).

Also in the SW data, there were examples of individual segments rather than tokens being variably produced. Sometimes these might be interpreted as a sign of progression since the variability was between an immature realisation and the adult target. For example, the voiceless alveolar fricative in SIWI position was realised as a glottal stop in SEESAW [ˈʔiʔɔ] but as the adult form in both tokens of SOCK. However, this positive interpretation might not apply readily to productions of the SFWF voiceless alveolar fricative /s/ realised variously in HOUSE [haʊːpʰ]; LIGHTHOUSE [ˈlaɪʔhaʊ̤ɹ̥]; MOUSE [maʊ̤ʔ]; PYJAMAS [ˈʔədɑ̃mə̃ʔs̪]. This last example showed realisation of the coda target, albeit with lenition, but it was preceded by a glottal stop which resulted in a perceptually atypical production. Variability was also evident in the unusual transitions between consonants and vowels described in section 6.11.1, where the duration was unpredictable. For example, the production of the labiodental fricative in onset was realised differently in FOOT [fːuʔ] and FISH [fɪ].

Examination of the CS samples revealed that the token to token variability seen occasionally in SW also occurred in conversational speech. Variable output was more difficult to quantify in MWU than in SW, but the occurrences were frequent enough in the six CS samples to provide examples of both phonetic and prosodic variation.

Example 1: token BROTHER

1) MY BROTHER (CS 6) [ˈmãɪ ˈbʌ(.)ˈdʌ]

2) MY BROTHER (CS 5) [mãɪ ˈbʌdə]

The two realisations of the word had the same onset, with the reduction of the consonant cluster to the single voiced bilabial plosive. However, in version 1 there was a within-word pause at the syllable boundary and the second syllable was realised with equal stress and a harmonised vowel, unlike version 2 which was realised with a typical trochaic pattern and typical vowels.

Example 2: tokens FIGHTING and OUTSIDE (CS 6)

1) WE BOTH START FIGHTING BUT HIM-WHEN WE WENT OUTSIDE [wi bəʊʔ ˈdɑʔ ˈfaɪʔɪn bəʔ ɪ˜n (.) ˈwɛ˜n wi (.) ˈwɛ˜nʔ ˈʔəʊ(.)ˈʔaɪd]

2) AND START FIGHTING OUTSIDE [ə˜n ˈdɑʔ ˈv̥aɪʔɪ˜n əʊʔaɪd˺]

The two realisations of FIGHTING were similar but showed differences in voicing of the onset labiodental fricative in spite of being preceded by the same word START which was realised in the same way each time, meaning that the difference was not obviously explained by phonetic context. The variability in OUTSIDE was the same as that seen in example 1, with a within word pause in the first token at the syllable boundary and a pattern of equal stress.

Example 3: tokens TRIPPED and OVER (CS 5)

1) THEN HIM TRIPPED OVER [ɛ˜n hɪ˜n ˈdiʔdɪd ˈʔəʊdə]

2) AND THEN HIM TRIPPED OVER-OVER [ə˜ˈnɛ˜nɪ˜n ˈdɪʔt ⁀əʊdə (.) ˈəʊvə]

In the first example Lily realised TRIPPED with an extra syllable to signal the past tense followed by the SIWW labiodental fricative in OVER being realised as a stop. In the second example she produced the past tense more typically in that there was no extra syllable, but she realised the SFWF cluster as a glottal stop with the target final consonant. Her initial realisation of this OVER was the same as version one but she then paused and self-corrected.

Example 4: token BRATZ (CS 3)

1) IT(S) BRATZ [ˈɪʔ ˈbæ̤ʔts]
2) WITH BRATZ PEOPLE ON [wɪd̚ ˈbæ̤ʔ ˈp͈ ip͈ ʊʷ ɒ̃n]
3) NICK THE BRATZ'(?STAR) [ˈnɪ̃ʔ də ˈpʰæ̤ʔ (ˈdɑ̤)]

All three examples show SIWI cluster reduction, but the third example also shows devoicing of the onset segment. In the first example, which occurred in an utterance-final position, Lily's realisation of the SFWF segmental sequence was one of the few examples in the whole T1 data set of a cluster where a fricative was produced.

Example 5: token NAMES (CS 1 AND CS 3)

1) BOTH OF THEM NAMES [ˈbəʊʔ wə dɛ̃m ˈnɛ̃ɪ̤md̥ː]
2) I DON'T KNOW THEM NAMES [ˈaɪ dəʊʔ ˈnəʊ̃ dɛn̚ ˈnẽɪ̤m̥]

These examples show Lily's atypical realisation of SFWF clusters (in this case resulting from a plural morpheme). In the first example she realised the target fricative as a stop with an audibly prolonged hold phase. In the second example she did not produce the second element of the cluster and the coda was produced with a weakly articulated bilabial nasal.

6.12 Speech behaviours in multi-word utterances T1

Lily's speech production was examined in conversational speech and imitated sentences. Firstly, an assessment of the characteristics of her speech at word boundaries was completed with an examination of how this compared to the multi-word speech of other children of the same age. Secondly, an exploration of some observations of prosodic aspects of her multi-word speech was carried out. The analysis so far had suggested that, in addition to pervasive segmental difficulties, her utterances were characterised by sometimes slow and effortful transitions between and within syllables and words. This impacted at all levels on the integrity of her utterances.

6.12.1 Word juncture in multi-word utterances T1

Lily's use of assimilation, elision and liaison, and close versus open juncture was examined in sentence repetition and in conversational speech.

6.12.1.1 Sentence imitation

The **Connected Speech Processes (CSP) Repetition task** (Stackhouse et al., 2007) was carried out to examine word juncture behaviours in imitated utterances (see table 6.8).

Table 6.8 Lily: Scores on the Connected Speech Processes (CSP) Repetition Task T1

	Score expected at age 7	**Lily's score**	**Examples of Lily's realisations, compared with typical 7-year-olds**
Assimilation			
t#	92.40%	25% (1/4)	EAT PUDDING [ˈip̚ pʊdɪŋ]→[ˈiʔ ˈp̼ ʊdɪ˜n]
n#	80.43%	75% (3/4)	JOHN PLAYED [ˈʤɒmpleɪd]→[dɒ˜m p̼ eɪ]
d#	43.18%	50% (2/4)	READ MY [ɹib̚ maɪ]→[wib̚ maɪ]
#ʃ	83.83%	0% (0/2)	Lily did not use /ʃ/; target MARY'S SHOES (NS 3) realised as [ˈmɛwi ˈʊ̃nd]
Elision			
Ct#C	86.94%	25% (1/4)	MUST CLEAN [ˈmʌsklin]→[ˈmʌʔ tĩn]
Cd#C	72.63%	50% (5/10)	JUDGED THE [ˈʤʌʤðə]→[ˈdʌʔ də]
Liaison			
j-liaison	91.94%	25% (1/4)	ME A [ˈmiʲ ə]→ [ˈmiʲ ə]
w-liaison	95.35%	0% (0/2)	YELLOW AEROPLANE [ˈjɛləʊʷ ɛəɹəˈpleɪn]→[ˈlɛləʊ ʔɛləˈve˜ɪn]
r-liaison	86.15%	100% (4/4)	WORE A [ˈwɔʴ ə]→[ˈvɔʷ ɪ] (/ɹ/→[w])
Articles			
Indefinite	No norms given	0% (0/2)	AN ELEPHANT [ən ˈɛləfənt]→[ə ˈʔɛləvə˜nʔ]
Definite	No norms given	0% (0/2)	THE ORANGE [ðiʲ ɒɹɪnʤ]→[də ˈʔɒwɪ˜n]

Lily's scores on the task suggested that development of word juncture was not at the level expected for her age for any of the between-word processes examined, although she was using assimilation, elision and liaison. For example, /j/-liaison occurred between the words ME and A in the utterance HE GAVE ME A BANANA realised as [ˈɪm deɪ ˈmiʲ ə ˈnɑ˜ˈnɑ̤] and alveolar/bilabial assimilation in THE BROWN BEAR EATS FISH realised as [də ˈbaʊ˜m ˈbɛə iʔ ˈf˘ɪʔtʼ]. However, the CSP task cannot allow definitive conclusions about word-final consonant elision when word-final glottal stops and cluster reduction were such frequently used processes. For example, the sentence SHE WRAPPED THE PARCEL was realised as [ɜʔ ˈwɛʔ də˘ ˈbɑ̤ːhə̤l]. The SFWF glottal stop in WRAPPED and the SIWI alveolar plosive have been segmented as /ˈwɛʔ/ and /də˘/; this assumes that /pt/ has been realised as a glottal stop and /ð/ realised as an alveolar stop, apparently demonstrating elision. An alternative approach could be to segment as [ˈwɛʔd ə˘/], with /pt/ realised as [ʔd] and /ðə/ as a neutral vowel. This interpretation would suggest that Lily was not using elision. These examples suggest that caution is needed in using this type of task when word-final consonants are subject to such significant constraints. As mentioned, there were examples of assimilation in the CSP task, suggesting this was an emergent skill. In the sentence YOU CAN READ MY BOOK, word final /d/ was assimilated to [b], so realised as [ˈju dəv ˈʋib˺ ˈmaɪ ˈbʊːkʼ]. However, SIWI bilabial segments were more likely to influence the preceding SFWF consonant than velars because potential assimilation contexts in this task were also affected by Lily's phonological processes. These resulted in SFWF glottal stop realisations as already described, and velar fronting. In the target sentence GOOD GIRLS ARE NICE, realised as [ˈd̪ʊʔ ˈd̪ɛld͡ɑ ˈnaɪ̤ːtʼ], the glottal replacement of word final /d/ in GOOD and the fronting of word-initial /g/ in GIRLS make it difficult to comment on assimilatory processes at this word boundary, because the assimilation context in typical adult speech production does not occur in Lily's speech output.

6.12.1.2 Word juncture in spontaneous, conversational speech

Some observations of word juncture in the sentence imitation task also held true for Lily's spontaneous utterances. There was emergence of w-liaison, for example, PEOPLE ON was realised as [ˈp̚ ip̚ ʊʷ ɒn] although she did not use /w/ liaison in the CSP task. Also j-liaison as in TINY AND TILLY realised as [ˈdaɪ˜niʲ æ˜n ˈdɪli̤]. /r/-liaison which typically develops later (Newton & Wells, 2002; Thompson & Howard, 2007) was also in evidence although realised as a glide as in THERE (S) A GIRL [ˈɛəʷ ə ˈdɛl]; THERE A PLUG FOR THE MP3 PLAYER [ˈɛəʷ ə ˈbʌg vɔʷ ə ˈɛ˜mˈbiˈvi ˈbeɪjə].

There were no examples of assimilation or elision in the conversational data, and this may be due to there being almost no opportunities for this at word junctures in the samples analysed. The one instance of potential assimilation occurred in the utterance AND GOLD (CS 3, T1) realised as [ɛ˜nʔ ˈdəʊd˺] where the assimilatory context of alveolar to velar plosive was affected by velar plosive fronting of the /g/ in GOLD. The opportunities for elision were reduced anyway because of the interaction between the realisation of SFWF segments and Lily's ability to produce SFWF syntactic structures such as past tenses. For example, in the utterance HIM FALLED OVER AND KICKED THE TIN (CS 6, T1) the regular past tense morpheme in KICKED would typically be subject to elision. Lily marked the presence of the past tense by using an additional syllable so the opportunity for elision was lost; [ɪ˜m ˈfɔdɪd əʊ‥dəʷ æ˜n ˈdɪʔˈdɪd də ˈdɪ˜n].

Lily's multi-word utterances showed frequent use of open juncture and as with the sentence imitation task, SFWF glottal stops affected many adult targets in conversational speech. However, there were also examples of close juncture and both types of word boundary can again be demonstrated using the example from CS 6, T1 (6.1); open juncture is marked O and close juncture C after Wells (1994).

Extract 6.1: Ladybirds

6.1.1. J. Right-and did you let them go or did you keep them?

C
6.1.2 L. Keep them

[ˈdip˺ ˈdɛ˜n]

C O O O O C C C C C
6.1.3 L. and then my brother said him going to let them

C C O C C
go and I said no

[nɛ˜n ˈmãɪ ˈbʌ(.)ˈdʌ ɛ‥ʰ ˈɪ˜n dʌ˜nə ˈlɛʔ ɛ˜n ˈdəʊ ə˜n ˈnɛ˜n ə aɪ ˈʔɛd˺ nə˜ʊ]

```
                  C     C  O     O     O          C
6.1.4. L. and then we both start fighting

      [ʷ ə˜nɛ˜nə˜ wi bəʊʔ ˈdɑʔ ˈfaɪʔɪn]

                C   O    O  O    O       O   O     O        C
6.1.5 → but him-when we went outside and start fighting

      [bəʔ ɪ˜n . ˈwɛ˜n wi (.) ˈwɛ˜nʔ ˈʔəʊ(.)ˈʔaɪd ə˜n ˈdɑʔ
ˈvaɪʔɪ˜n]

       O   O    O      C    C    C      O    O    C   C   C
 outside him-him falled over and kicked the tin and all

    C          C  C
 the ladybirds got out

[əʊʔaɪd˺ ˈɪ˜m ɪ˜m ˈfɔdɪd əʊ..dəʷ æ˜n ˈdɪʔˈdɪd də ˈdɪ˜n æ˜n ˈɔl

də ˈlɛɪdibɜd˺ dɒʔ ˈəʊ..ʔ]
```

Close juncture was observed in high frequency word combinations, for example, line 6.1.3 `going to let them go`, and also in the last few words of the utterance, line 6.1.5, (which was turn-end) `and all the ladybirds got out.` This was characteristic generally for her conversational speech. However, the long sequences of open juncture were striking and these affected not only between-word contexts but also within-word syllable junctures, as in line 6.1.3 `brother` and 6.1.5 two instances of `outside`. In this respect Lily is similar to the child "Zoe" described by Wells (1994) who also used open juncture at syllable boundaries. Like Zoe, it may be that Lily found it difficult to balance the demands of syntagmatic fluency "the need to realize phrases and sentences as cohesive wholes" (Wells, 1994, p. 2) in the context of her highly constrained segmental system. Further evidence of these difficulties can be seen in observations of her prosody in MWU, described in the next section.

6.12.2 Prosodic characteristics

Lily's atypical segmental transitions have been described in terms of duration (section 6.11.1) and these impacted on the overall quality of her conversational speech as well as at SW level. The perceptual impression was of slow rate and frequent pauses, but further analysis also showed stretches of syllable-timed speech related to open juncture between words and frequent glottal stops. For example, in IT KEEP ON NIPPING PEOPLE (CS 1, T1) realised as [ɪʔ ˈbiʔ ɒ˜n̊ ˈnɪ͜ʔˈbɪn ˈbiˈbə..ʊ] the 2 syllable words NIPPING and PEOPLE were delivered with equal stress on each syllable rather than the strong-weak trochaic pattern typical of British English (Wells, 1994). Another example was seen in MP3 PLAYER (CS 2, T1) [əʔ ˈɛmˈbiˈf˜i ˈbeɪjə̤] realised with equal stress on all three syllables in MP3.

In addition to open juncture at word boundaries, Lily also had frequent pauses in multi-word speech which appeared to be related to language formulation or word-finding difficulties resulting in repetition and repairs. For example, P-P-ON –MUSIC ON THE- P-COMPUTER (CS 2, T1) realised as [p' (.) p' (.) ɒ˜n (.) ˈmʊ̃dɪʔ ɒ˜n də (.) p' (.) ˈbuˈʔɑ̤]. Occasionally these pauses offered a possible insight into levels of processing underlying Lily's speech output. For example, an utterance in conversation was NEAR MY DAD'S HOUSE, realised as [ˈnɪ˜ə mãɪ ˈdæd̚ (.) hə̤z̥̚ (ə̚) ˈʔaʊ̤ːt']. Assuming that the interpretation of Lily's intended meaning was correct, which it appeared to be contextually, the pause and the following segmental sequence [(.) hə̤z̥̚ (ə̚)] might be viewed as an attempt to realise the possessive morpheme /s/. Lily rarely produced SFWF /s/ or /z/ and in the conversational speech samples there are only two examples of alveolar fricatives, both in utterance-final positions, and both marking the plural morpheme "s": AND DOCTORS realised as [æ˜n ˈdɒʔdəd̚s] and IT'S BRATZ realised as [ˈɪʔ ˈbæ̤ʔts]. In SW the only examples of SFWF alveolar fricatives also occurred in plural items LEGS realised as [lɛg̊ts̬] and PYJAMAS as [ˈʔədɑ˜mə˜ʔs]. All examples were devoiced. Lily's unsuccessful attempt at producing the possessive morpheme "s" within the utterance MY DAD'S HOUSE reflected the difficulty alveolar fricatives posed for her. However, even though her production was atypical and sounded effortful, her attempt suggested that her underlying phonological representation for this target was accurate, as must be the case in the examples of accurate realisations of plural morphemes. This strengthens an argument for motor and articulatory constraints being a major factor in Lily's inaccurate word production.

In addition to the effects of open juncture and extended duration which could be classified as hyperarticulation (Howard, 2007a), Lily also showed typical reduction behaviour in conversational speech with appropriate intonation, rate and rhythm in high frequency utterances. For example, in CS 5, Lily realised the words AND THEN HIM as [əˈnɛ˜nɪ˜n] and THEN HIM NOT as [nɛ˜ˈnɪ˜nɒ˜ʔ]. This feature was less frequent than hyperarticulation but important as evidence of typical speech behaviour, even though with her significantly reduced segmental system this increased the risk of limiting intelligibility (although content words were not generally affected).

6.13 Voice quality

Lily's voice quality was noticeably breathy and dysphonic. There was variation both within and across utterances; the breathy quality was frequently more pronounced at turn end. On occasions her voice quality on vowels also showed variation in intensity during production giving a slightly aperiodic effect. Breathiness has been described as voice produced with "relaxed and incomplete closure of the vocal folds" (Epstein, 2002, p. 9); the term "unconstricted" laryngeal setting has also been used (Benner, Grenon, & Esling, 2007, p. 2073). Lily's voice quality appeared related to what Harris and Cottam (1985) term "articulatory strength" (p. 65). Although Lily's consonant output showed, for example, much more frequent use of plosives which require more articulatory strength than fricatives, her frequent use of glottal stops (the extreme form of gestural simplification) and her management of consonant-vowel transitions at times gave the impression of articulatory effort. Her performance on the non-speech oro-motor tasks had also shown poor power and precision. Lily's breathy voice was interpreted as symptomatic of her overall motor difficulties which affected her whole vocal tract including laryngeal and respiratory levels.

6.14 Summary of findings at T1

Lily's input processing skills and speech output skills at T1 were summarised as follows: (see also her speech processing profile appendix 6.2, and 6.3 for the mapping of this profile to the speech processing model).

- Input processing skills showed mild difficulties discrimination and judgement tasks with real words, more so if they were multisyllabic; tasks involving non-words were more difficult

- Scores for the mispronunciation detection task were within the normal range suggesting underlying phonological representations for these items were accurately defined

- The single real word naming test indicated severe difficulties with word production; imitation of these same words was also severely impaired

- The non-word repetition test showed that Lily also had a severe level of difficulty in this task, corresponding to naming and real word repetition; similarity in performance across these three tasks together suggested either significant articulatory or phonological constraints

- Lily's performance on oro-motor tasks suggested that she had some difficulties with precision and power in non-speech movements

- Lily's performance on the DDK task indicated significant difficulties with motor planning

- Her phonetic inventory indicated a reduced number of English consonant phones

- Her vowel inventory included all appropriate English vowels although there was some variability in vowel realisation

- Her PCC was 44.90% and her PVC was 92.06%% giving a PPC of 68.48%. corresponding to a severe level of difficulty

- Findings from the phonological processes analysis of Lily's speech were that she had multiple structural and systemic processes including both typically delayed patterns (velar fronting; cluster reduction) and atypical patterns (glottal replacement of SIWI and SIWW fricative targets)

- Other findings included atypical management of transitions between segments at syllable and word level

- She had a breathy voice quality

- Her atypical and effortful production of words, for example, her attempts to produce fricatives (including morphological markers) suggested that her underlying phonological representations for those targets were accurate and that motor and articulatory constraints were a major factor in word production

- Word juncture behaviours suggested that liaison and assimilation were emerging but word-final segmental difficulties significantly affected production, with an impact from high rates of glottal stop realisations

- Overall, Lily's speech was characterised by extended and slow realisations in SW and MWU with open juncture at word boundaries which might be described as hyperarticulation
- On occasions she showed appropriate reduction in conversational speech but this also potentially compromised intelligibility because of her low PCC

The impact of these difficulties on Lily's intelligibility as experienced by the listeners who participated in the study was explored.

6.15 Intelligibility T1

Lily's intelligibility was measured through listener responses to an orthographic write-down task for single words, imitated sentences and conversational speech (as described in Chapter Three, Methods); results are presented in table 6.9. Stimuli from Lily's speech output that were presented for intelligibility rating are given in full in appendix 6.12 and in tables 6.13, 6.14 and 6.15.

Table 6.9 Lily: Intelligibility outcomes T1: Percentage (and number) of items correctly identified by listeners

Data type	Mean % (No.)	S.D. % (No.)	Minimum score % (No.)	Maximum score % (No.)
Single words (max no. = 11)	23.41 (2.58)	15.79 (1.73)	0 (0)	63.64 (7)
Imitated sentences (max no. = 24)	36.42 (8.74)	11.23 (2.69)	12.50 (3)	62.50 (15)
Conversational speech (max = 100%)	40.09	17.84	3.57	75.00

Analysis of results using the Wilcoxon Signed Ranks Test demonstrated that the listeners' identification of Lily's single words was significantly poorer than that of multi-word utterances. There were significant differences between SW and imitated sentences ($Z=-5.387$, $p<.0001$) and SW and conversational speech ($Z=-5.890$, $p=<.0001$). There was no significant difference between imitated sentences and conversational speech ($Z=-1.650$, $p<.099$).

All types of utterance showed a wide range of listener responses, as evidenced by the minimum and maximum scores and the large standard deviations (see Table 6.9). In terms of the individual stimuli items, in SW PRAM was least well recognised with 0/66 listeners identifying it; CAR was best identified with 51/66 correct responses. The least well recognised imitated sentence was JOHN COLLECTS STAMPS with 0.3% of words identified (one listener, L21, recognised one word of this utterance), although HE JUDGED THE COMPETITION with a score of 0.76% was similarly poor (two listeners, L21 and L38, identified one word each of this utterance). The best recognised imitated sentence was MY LEFT LEG HURTS with 87.27% of words identified. In conversational speech I ACTED AND SINGED was least well recognised, with 17.42% of words identified; the best was WE MAKED DECORATIONS with 66.36% of words intelligible. These intelligibility results are discussed in section 6.26.5.

6.16 Activity between T1 and T2 (7;3 to 8;10)

In the 20 months between T1 and T2 Lily participated in weekly individual speech and language therapy intervention sessions which were regularly followed up at school and at home. Intervention focused on perception and production of alveolar and post-alveolar fricatives, velars, clusters and affricates. Therapy included using grammatical tasks as a focus for both sentence structure and speech sound targets. Examples included the realisation of SIWI fricatives in "he/she"; complex SFWF segmental combinations (consonant clusters) in past tense and plural production. Activities building on phonological awareness continued throughout the intervention, supporting the development of both input and output skills.

6.17 Assessment (C.A. 8;10) T2

Twenty months after the first assessment at T1, Lily's input processing skills and speech output skills in single words and multi-word utterances were reassessed (see appendix 6.13 for her new speech processing profile and 6.14 for the mapping of this profile to the speech processing model). The aim of this reassessment was to collect sufficient data to describe any significant changes in Lily's skills and also to examine her intelligibility at T2 as judged by the listeners (see Chapter Three, Methods).

6.18 Input processing skills T2

The investigation of Lily's input processing skills included assessment tasks from Stackhouse et al., (2007) and other non-standardised activities.

Lily's speech perception was examined again through the judgements of same/different SFWF single feature and s-cluster sequences in real words and non-words, for example, lots/lost; vots/vost, (Stackhouse et al., 2007). Normed scores were not available for children of her age so her score was compared to that of typical 7-year-olds. Lily's overall score was 33/36, z=-2.97. At T1 her score had been 30/36, z=-6.64. Real word scores were unchanged from T1 (16/18, z=-2.2) but non-word scores were better (17/18, z=-1.2 at T2 compared with 14/18, z=-7.2 at T1). These scores suggest an improvement over time in her performance. However, because Lily was still making some errors at 8;10, and the mean score for typical 7-year-olds was 35.35/36, the results suggest that she had an ongoing vulnerability in speech discrimination.

Speech discrimination of complex non-words was reassessed (Stackhouse et al., 2007), for example, "same or different, /gəˈtɔ/ /təˈgɔ/". Lily's score was again compared to the norms for typical 7-year-olds. She scored 85% (z=-0.5) correct compared with 75% (z=-1.42) at T1. Her score was in the typical range for 7-year-olds but her persisting errors at T2 were at least suggestive of ongoing difficulties in perception of complex phonology and, from this particular task, perhaps vulnerability with novel words.

Lily's auditory lexical discrimination skills (ALD) were reassessed using two tasks. The first task, mispronunciation detection, was with picture support, recognising production errors in 1, 2 and 3/4 syllable words (Stackhouse et al., 2007). At T2, Lily's score was 100% correct for all word structures, compared with 94.16% at T1 when her performance had indicated a mild level of difficulty with 3/4 syllable words. Her score suggested that phonological representations for the words presented were accurate. The second task was without pictures (Stackhouse et al., 2007), deciding whether heard words were real lexical items or not; for example, "binoculars"; /ˈkæpətɪlə/; /ˈhɒspɪpəl/. This task was not carried out at T1 but was included at T2 to further investigate real word and non-word perception. No norms are available for children of Lily's age but typically-developing children reach ceiling levels at 6;0. Lily's score was 90% (9/10) for real words (her one error was in rejecting 'escalator' as a real word); for non-words she scored 100%. This suggested that her underlying phonological representations were sufficiently developed for her to judge whether she was hearing a real word or not. Acceptance of non-words that are close matches to real words, is suggestive of underlying 'weak or fuzzy' representations (Waters, 2001, p. 175).

Overall, although Lily still showed some vulnerability in segmental perception of complex phonology, she had progressed between T1 and T2 at least in terms of her own performance as measured by raw scores.

Lily's skills in the activities covered by the Test of Phonological Awareness (Hatcher, 1994) had developed and she scored 30/36 compared with 17/36 at T1. Lily was reliably able to identify words from given syllables (e.g. win-dow) or phonemes (e.g. s-ou-p) and identify rhymes from a choice of 3 heard words without adult help (e.g. net, ten, pen). She could segment CVC, CCVC and CVCC words into phonemes. She was able to carry out the phoneme deletion task with CVC words although still found it difficult to do this in words which contained consonant clusters. She attempted the phoneme transposition task (e.g. "net" reversed is "ten") but still found this difficult. Along with these phonological awareness skills, Lily's literacy skills had developed since T1 and she was reported by her class teacher to be performing at the same level as her peers in reading, spelling and written language.

6.19 Speech output tasks T2

Lily's speech production was re-assessed using a range of single word tests as at T1; the Picture Naming Task (Stackhouse et al., 2007), the Non-word Repetition Task (Stackhouse et al., 2007) and subtests of the DEAP (Dodd et al., 2002) gave 109 items collected from these tasks for single word (SW) analysis which was the same as at T1 (appendix 6.4). The multi-word data are from the analysis of T2 conversational speech (CS) (appendices 6.15 to 6.19) and selected imitated sentences from the Connected Speech Processes (CSP) Repetition Task (Stackhouse et al., 2007), (appendix 6.11); there are occasional examples from other conversational speech, which are indicated in the text.

Lily's performance on the Picture Naming Task (Stackhouse et al., 2007) and the Non-Word Repetition Task (Stackhouse et al., 2007) were scored, and in the absence of norms for 8-year-olds, they were compared to that expected in the speech of typical 7-year-olds; scores were also compared with T1 (see table 6.10).

On the Picture Naming Task (Stackhouse et al., 2007) Lily's overall score across all word lengths was 49/60 (81.66%), z=-1.32, compared with 28/60 (46.66%), z=-5.53 at T1. These scores for real words equate to the normal range for 7-year-olds. Even given that Lily was now 8;10, this suggested that she had made progress across all lengths of words.

Table 6.10 Lily: Scores Picture Naming and Non-Word Repetition Tasks T1 and T2

	The Picture Naming Task (real words)			**Non-word Repetition Task**		
Word structure	Lily's score T1 (z-score)	Lily's score T2 (z-score)	Real word norms age 7 years: mean (S.D.)	Lily's score T1 (z-score)	Lily's score T2 (z-score)	Non-word norms age 7 years: mean (S.D.)
1 syllable (N=20)	4 (-12.33)	17 (-1.5)	18.8 (1.20)	5 (-5.87)	17 (0.50)	16.05 (1.88)
2 syllable (N=20)	3 (-12.07)	17 (-1.13)	18.45 (1.28)	3 (-7.34)	12 (-2.60)	16.95 (1.90)
3 & 4 syllable words (N=20)	0 (-7.27)	15 (-0.83)	16.95 (2.33)	1 (-6.35)	9 (-2.91)	15.80 (2.33)
Total (N=60)	7 (-12.01)	49 (-1.32)	54.2 (3.93)	10 (-8.33)	38 (-2.32)	48.85 (4.66)

On the Non-Word Repetition Task (Stackhouse et al., 2007) Lily scored 38/60 (63.33%), z=-2.32, compared with 10/60 (16.66%), z=-8.33 at T1. However, unlike real words, scores were very different for 1, 2 and 3/4 syllable words; 1 syllable words were in line with typical scores for 7-year-olds but scores for longer words indicated an ongoing difficulty. This is suggestive of problems in motor programming, with greater impact as word length increased. Her imitation of non-words showed inaccuracies and difficulty in repetition of complex segmental sequences. For example, /ˈsɛsəʤ/ was realised as [ˈslɛsɪʤ]; /spʌˈgɪtə/ as [spʌˈslɪkə]; /kɛmˈpjaʊti/ as [kɛmbəˈləʊti]. Her naming of the real words matched to these items was [ˈsːɒsɪʤ] (SAUSAGE), [skɛt̜i] (SPAGHETTI) and [ˈkʰ ɒ̃mp(.)ˈbutə..̠] (COMPUTER). These still showed segmental differences but were arguably more accurate than their non-word counterparts. These results suggested that Lily was establishing more accurate motor programmes for familiar lexical items but her continuing difficulties in perception of complex segmental patterns and/or motor programming meant that novel words were still subject to being inaccurately repeated.

Lily's progress in naming tasks was also seen in terms of her overall percentage correct in the production of consonants and vowels. Lily's PCC was 90.41% (44.90% at T1) and her PVC was 96.80% (92.06% at T1), giving a PPC of 93.60% (68.48% at T1). Her severity rating for consonant production (Shriberg and Kwiatkowski, 1982) progressed from a severe level at T1 to a mild level at T2.

6.20 Oro-motor skills and diadochokinesis (DDK) T2

Lily's oro-motor skills and DDK rates were unchanged since T1. She was not able to elevate her tongue tip, and both isolated and sequenced movements lacked power and precision. She was still unable to repeat the sound sequence [p-t-k] with any sustained accuracy or fluency. She was given written support to produce an alternative sequence [b], [d], [g] but still made occasional errors even when reading the sequence, for example, [b, g, g], It was concluded that Lily still had oro-motor and motor planning difficulties.

6.21 Phonological process analysis T2

A phonological process analysis was again completed using data primarily from single words and conversational speech, supplemented by data from imitated sentences.

Lily's speech had changed both in single words and in MWU; some processes had disappeared and others remained but occurred less frequently. Examples are given in table 6.11.

Table 6.11 Lily: Examples of phonological processes in SW and MWU T2

	Comments	Examples
Structural processes		
Weak syllable deletion	Still evident in SW and MWU but to a much lesser extent	GUITAR [tʰ ɑ̤] (SW); HIDED uh-uh BEHIND [ˈhaɪɖɪɖ ʌʔʌʔ ˈʔaɪ˜nʔ] (CS 2, T2)
Final consonant deletion	Resolved	N/A
Cluster reduction	Largely resolved in SW; occasional examples in MWU	SHE MY FRIEND TOO NOW [si ˈmãɪ ˈf˘ɛ˜n͡ ˈtʰ u nãʊ̤] (CS 2, T2);
Systemic processes		
Glottal replacement	SIWI and SIWW resolved. SFWF largely resolved in SW but still evident in MWU	FOR THE FIRST TIME [fɔ də ˈfɜʔ ˈt˭ aɪ˜m] (CS 4, T2)
Velar fronting	Resolved	N/A
Deaffrication	Resolved in SW; SFWF often realised in an immature form in MWU	AND THE BEACH [ə˜n də ˈbitsː] (CS 5, T2)
Stopping	Resolved for all segments apart from /z/ in SW and MWU, /ð/ in MWU & rarely /s/ in MWU	WHEN WE SAW HORSES BOBBY WOULD SAY [wɛ˜n wi sɔ̤d ˈhɔsɪd̥ ˈbɒbi wʊd͡ ˈde̤ɪ] (CS 1, T2)
Gliding	Resolved	

Voicing	Largely resolved in both SW and MWU; occasional examples in all contexts	SHE WRAPPED THE PARCEL (imitated sentence) [si ˈɹæp̥ də ˈbɑʃəʊ]

6.21.1 Structural processes T2

The main structural process in evidence at T2 was cluster reduction, and this was mainly in multi-word utterances. In the SW assessment Lily produced 32 SIWI/SIWW consonant clusters, 96.87% (31/32) were realised with all segments present; the one exception was /kr/ in CROCODILE which was reduced to [k]. At T1 she had reduced 93.33% (18/20) clusters to a single element. Her T2 cluster realisation included two triple /s/ clusters in SQUARE and SPLASH. In CS there were 21 SIWI/SIWW consonant clusters. 71.42% (15/21) of these were realised with two elements; the others were reduced to a single segment. For example FRIEND was realised both as [fɹɛ˜nd] and [fˇɛn] in the same utterance. There were other examples of this type of variability in close proximity to each other. In the utterance WALKING ABOUT AND EVERYONE STROKED IT AND IT DIDN'T DO NOTHING (CS 1, T2) realised as [ˈwɔkɪ˜n əˈbaʊːʔ nɛ˜vn̩ ˈɹəʊʔ ɪʔ æ˜nɪ˜ʔ ˈdɪdn̩ d̥u ˈnʌ˜fɪ˜ŋ], /str/ was reduced to the post-alveolar approximant. Immediately following this simplified production, it was realised accurately; AND THEN IT LAY DOWN AND STROKED IT AND KISSED IT AND EVERYTHING [ə˜n͡ nɛn ɪʔ ˈleɪ ˈdaʊ˜n æ˜n ˈstɹəʊʔ. ˈdɪʔ æ˜n ˈkʰ ɪ̤ʔ bɪʔ æ˜n ˈɛvəˈfɪ˜ŋk'].

SFWF clusters were usually realised with two elements in single words but still frequently reduced and/or realised as a glottal stop in multi-word utterances. SFWF nasal clusters were accurate. In CS the six examples of SFWF /st/ were always replaced with a glottal stop, for example, FIRST realised as [fɜʔ] and FOREST as [ˈfˇɒɹɪʔ].

The other structural process in evidence, although with reduced frequency in both single words and connected speech, was weak syllable deletion. In the SW samples GUITAR was realised as [tʰ ɑ̤] and SPAGHETTI as [ˈskɛt̬i]. In conversational speech there were similar examples including BEHIND in the utterance HIDED UH-UH BEHIND [ˈhaɪd̬ɪd̬ ʌʔʌʔ ˈʔaɪ˜nʔ] (CS 2, T2).

6.21.2 Systemic processes T2

The systemic processes in Lily's speech also showed improvement. Glottal stop realisations of consonant segments (apart from SFWF /t/ which was an acceptable variant in Lily's accent) had reduced overall. In SW they occasionally occurred with SFWF /k/ (40%, 2/5) but were otherwise not a feature of her speech in single words. Notably, SIWI and SIWW fricatives were realised typically with the exception of inconsistent fronting of post-alveolar fricatives in MWU. However, in conversational speech SFWF glottal replacement was still frequent. For example in the utterance WALKING ABOUT EVERYONE STROKED IT AND IT DIDN'T DO NOTHING (CS 1, T2) glottal stops were appropriately used for WF /t/ but also for the past tense marker in STROKED /stɹəʊkt/ which would typically be realised as [t] preceding a vowel, as in this context: [ˈwɔkɪ˜n əˈbaʊːʔ nɛ˜vn̩ ˈɹəʊʔ ɪʔ æ˜nɪ˜ʔ ˈdɪdn̩ d̥u ˈnʌfɪ˜ŋ].

Velar fronting had resolved in both SW and CS. However, in SW the velar nasal was realised as [ŋ] in SFWW positions (2 examples) but in SFWF position as [ŋk'] on all occasions it was used. This possibly reflected a sociophonetic variant appropriate for Lily's linguistic community where, for example, SOMETHING would be realised by many speakers as [ˈsʌmfɪ˜ŋk]. In MWU all velar nasals occurred in SFWF position; 4 were realised as [ŋ] and 1 (in utterance final position) as [ŋk']. All other realisations of SFWF / ŋ / (12 examples) were [n] and were tokens of the present progressive morpheme -ING; this was also compatible with Lily's accent.

Realisation of affricates had developed. In SW all Lily's affricates were realised correctly (11 examples) in all positions (at T1 none were). In conversational speech /ʧ/ occurred on 3 occasions, all in SFWF position and 2/3 were accurate. /ʤ/ was a target on 13 occasions (all SIWI or SIWW) and 46.15% (6/13) realisations were accurate; the relatively high number of examples of /ʤ/ in the data was because she used the name NIGEL several times and often stopped the affricate, for example, NIGEL SAID I DON'T WANT TO GO TO THIS JLS realised as [ˈnãɪdəʊ ˈsɛd̥ ɔɪ ˈdəʊ˜nʔ wɒ˜nə ˈgəʊ tə vɪs ˈʤeɪlɛs].

Other systemic processes, namely stopping and voicing, had largely resolved; there were occasional examples of residual processes in multi-word speech (see table 6.11) and SFWW and SFWF /z/ was usually realised as an alveolar or glottal stop or affricated in all contexts as in SCISSORS realised as [ˈsɪdəd̥s]. Lily also tended to realise SIWI [ð] as [d] in high-frequency words such as THE, otherwise [θ] and [ð] were realised as [f] and [v]; this was not uncommon among Lily's peer group. Gliding had resolved completely.

In spite of the progress that was evident in Lily's speech she still produced atypical realisations, which were particularly evident in her production of complex segmental sequences. For example, in her attempts at the words JET SKIS (CS 5, T2) in Extract 6.2.

Extract 6.2 Jet skis

6.2.1 J: What do you like doing on the beach?

6.2.2→L going on the jet skis

[ˈgəʊɪ̃n ɒ̃n ə ˈsgɛʔ ˈdid̪s]

6.2.3 J: on the?

6.2.4→L: jet skis

[sgɛʔ ˈsdid]

6.2.5 J: Oh, the jet skis

6.2.6 L→: jet skis

[ˈʤɛʔ ˈstid̪s]

Her first attempt (line 6.2.1) was not understood; it appeared to involve a difficulty with phonological assembly with the /s/ cluster instead of the affricate realised as the onset to jet and a plosive as the onset of skis which may have been an immature realisation of the affricate.

On the second try (line 6.2.4) Lily modified the onset of skis to produce an /s/ cluster although the second element was an alveolar rather than velar plosive. Her third attempt (line 6.2.6) was after modelling and she successfully realised the adult target affricate in jet although her realisation of the /s/ cluster still had an alveolar rather than velar plosive and she produced an affricate on the coda position. This example illustrates Lily's ongoing vulnerability in output, particularly with complex phonetic sequences.

The phonological process analysis indicated that Lily's speech production had progressed between T1 and T2 and both structural and systemic difficulties were resolving as had been indicated by the results of her Picture Naming Task (Stackhouse et al., 2007) and PCC results. There was variability between single words and multi-word utterances, with immature glottal replacement patterns and difficulty in fricative production still significant in multi-word speech. The next part of the analysis was to consider other aspects of Lily's speech output that had not been captured by a phonological process analysis.

6.22 Features not captured through phonological process analysis T2

As at T1, the phonological process analysis revealed a wealth of information from single words and in multi-word utterances which contributed to the description and explanation of Lily's speech patterns and intelligibility. However, a wider analysis was necessary in order to re-examine the other features (such as atypical segmental transitions and durations) which could not be accounted for through a traditional phonological process analysis approach. In addition the production of vowels, segmental variability and word juncture behaviours in multi-word utterances were explored.

6.22.1 Vowels

Lily's realisation of vowels in the single word sample at T2 showed only two non-adult forms which were both similar to realisations at T1 and involved vowel production in unstressed syllables. These were in COMPUTER realised as [ˈkʰ ɒ˜mp(.)ˈbutə̤̣] and FEATHER realised as [ˈfːɛvɑ̆]. In the first example, Lily appeared to have difficulty in managing the syllable boundary, or possibly the integrity of the word shape as a whole, given that she sometimes still deleted weak syllables. The first vowel in the word, typically realised as a neutral schwa, was realised fully instead as it would be in a single syllable word. The second example, where typically a schwa would be used she produced the open back vowel [ɑ̆] instead of the target. There is no obvious reason for this, other than it being the type of realisation seen at T1 which may reflect a motor planning issue.

6.22.2 Segmental transitions and duration

The atypical transitions between segments, which had been so characteristic of Lily's speech at T1 had improved. However, residual traces occurred in single words, most often (but not only) related to the production of fricatives. This involved a longer duration on continuant sounds or a longer hold phase with plosives. SIWI examples included VAN realised as [v̩ːæ˜n]; YELLOW as [jːɛləʊ̤]; STRAWBERRY as [ˈstːɹɔ̤bɹi]; QUEEN as [kːwĩn]. In SFWF positions, a glottal stop before a fricative or affricate target was common, which affected the overall timing of these vowel to consonant transitions for example, WATCH realised as [wɒʔʧ˺]; HOUSE realised as [haʊʔs]; TOOTHBRUSH realised as [ˈtuʔfːbɹʌʔʃ].

As already discussed in section 6.21.2, fricative production was not entirely established and this occasionally led to transitional problems that affected both duration and prosody. For example, in the utterance WE NEEDED A DRESS - THERE WAS A COMPETITION (CS 2, T2) realised as [wi ˈnidɪd ə ˈdɹɛʔːsː (.) v̩ ɛə wɒd ə ˈkʰ ɒ̃nɪtɪʃə̃n], the transition from the vowel in DRESS to the production of the SFWF /s/ involved Lily prolonging the hold in the glottal stop before then producing a long alveolar fricative. Perceptually (and actually) this meant there was a pause which disrupted the overall timing of the word. Arguably this was more prosodically disruptive than the SFWF stop realised for the target /z/ in WAS in the same utterance. These persisting difficulties in fricative production together with the finding that her oro-motor and motor planning skills were still significantly impaired, suggested that the motor and articulatory constraints underlying her speech output had not entirely resolved.

6.22.3 Variability

At T2 Lily's speech was still subject to segmental variability in relation to single word and multi-word utterances as described in section 6.21.2. She had inconsistency in more recently established patterns which had actually led to an increase in variability; this was often progressive as she self-corrected, with realisation of more accurate adult forms. Lily would also attempt to change the realisation of a given word when her output was queried, as in the example given in extract 6.2, although repeated attempts were not always successful.

6.22.4 Voice quality

The breathy voice quality evident at T1 was still much in evidence at T2 although perceptually Lily's speech output was less effortful. There was perhaps a little more variability in phonatory patterns and occasional stretches of typical-sounding modal voice. However, the overall presentation was of persisting mild to moderate dysphonia.

6.23 Word juncture in multi-word utterances T2

As at T1, Lily's use of assimilation, elision and liaison, and close versus open juncture was examined in sentence repetition and in conversational speech. This was first explored using the Newton Sentences Connected Speech Processes (CSP) Task (Stackhouse et al., 2007), (see table 6.12). Norms were not available for children of Lily's age so the data were compared to those of 7-year- olds and to Lily's scores at T1.

Table 6.12 Lily: Scores on the Connected Speech Processes (CSP) Repetition Task T1 and T2

	Lily's score (%) T1	Lily's score (%) T2	Score expected at age 7 (%)
Assimilation			
t#	25 (1/4)	75%(3/4)	92.40
n#	75 (3/4)	50 (2/4)	80.43
d#	50 (2/4)	75 (3/4)	43.18
#ʃ	0 (0/2)	50 (1/2)	83.83
Elision			
Ct#C	25 (1/4)	75 (3/4)	86.94
Cd#C	50 (5/10)	50 (5/10)	72.63
Liaison			
j-liaison	25 (1/4)	100 (4/4)	91.94
w-liaison	0 (0/2)	100 (2/2)	95.35
r-liaison	100 (4/4)	100 (4/4)	86.15
Articles			
Indefinite	0 (0/2)	0 (0/2)	No norms given
Definite	0 (0/2)	0 (0/2)	No norms given

In the sentence imitation task Lily's use of liaison had developed since T1 and she was consistently using all types appropriately at word boundaries. Her use of the post alveolar approximant [ɹ] had also developed and this was evident in liaison. For example:

Target: (NS 20) I WORE A JUMPER

T1 [aɪ ˈvɔʷ ɪ ˈdɛ˜nʔbʌ̤]

T2 [aɪ ˈwɔʴ ə ˈʤʌ˜mpə̤]

Appropriate realisation of assimilation processes had continued to develop; for example:

Target (NS 15) GOO<u>D</u> GIRLS ARE NICE

T1 [ˈdʊ̤ʔ ˈdɛ̤ldɑ ˈnãɪ̤ːt']

T2 [ˈgʊg˺͡ ˈgɛʊd ɑ ˈnaɪs]

In this instance the SFWF segment in GOO<u>D</u> was realised as a glottal stop at T1 but at T2 the alveolar plosive was assimilated in a typical manner to a velar place of articulation.

Reduction in the production of SFWF glottal stops had also led to evidence of the emergence of elision; for example:

Target (NS 14) SHE WRAP<u>PED</u> THE PARCEL

T1 [ɜʔ ˈwɛʔ də˘ ˈbɑ̤ːhə̤ʊ]

T2 [si ˈɹæp͡ də ˈbɑʃəʊ]

In this example the SFWF past tense ending of WRAP<u>PED</u> was realised as a glottal stop at T1 but at T2 it was realised in a typical manner.

In conversational speech there was also evidence of more mature speech behaviours at word boundaries, although glottal stops, and immature verb tense endings, continued to impact on the opportunities for their occurrence. In the utterance MY FRIEN<u>D</u> TOO NOW (CS 2, T2) realised as [ˈmãɪ ˈf˘ɛ˜n tu nãʊ̤], Lily showed appropriate use of elision in deletion of the SFWF /d/ in FRIEND. There was an example of appropriate velar assimilation in the utterance LEAH ALWAYS ASK(S) IF I CA<u>N G</u>O ON ONE (CS 5 T2) realised as [ˈliəʔ ɔˈweɪd̩ ˈɑs ɪʔ ˈaɪ kʰ ə˜ŋ ˈgəʊ ɒ˜m ˈwʌ˜n].

Lily's ability to manage word boundaries with close juncture had developed; an example is given in extract 6.3 (from Holiday CS 2, T2).

Extract 6.3

```
                C  C     C    C    C    C         C  C  O
6.2.1 But we didn't stay that long because it was

           C   O
getting cold

[ˈb̩ʌʔ ˈwi dɪdə˜nt ˈsteɪ væʔ ˈlɒ˜ŋ bɪˈkəd ɪʔ wəd̚ ˈgɛ˜ːŋ ˈk̚ əʊd̩]

           O  O   O   C  C       C   O   O   O    C    C C
6.2.2 And um-well-um-my cousin went to get some money to

  C          C  C  O
get something to eat

[æ˜nd ʌ˜m wṵ ʌ˜m͡ ˈmaɪ ˈkʰ ʌd̩ə˜m wɛ˜nʔ əʔ gɛʔ ˈsʊ˜m͡ ˈmʌ˜ni d̩ə
ˈgɛʔ ˈsʌ˜ɱɪ˜ d̩əʷ ˈiʔ]

          C  C   C  C  O   C  O  C   C
6.2.3 so me and my mate was um on our own

[səʊ̤ ˈmijʌ˜m͡ maɪ ˈmeɪʔ wɒd̩ ʌ˜m ˈʔɒ˜n ɑʲ ˈəʊ˜n]
```

In this example close juncture was Lily's preferred style. Open juncture occurred in conjunction with hesitation as at the beginning of line 6.2.2 `And um-well-um-my cousin` and where the occurrence of stops at times interfered with juncture. Lily's ability to produce MWU was much more adult-like than it had been at T1, although there was still evidence of atypical segmental realisations impacting on her speech output.

6.24 Summary of findings T2

Assessment at T2 demonstrated convincing evidence of changes in Lily's speech production. This was measured through a variety of tasks including PCC where she scored 90.41% (44.90% at T1) and the Picture Naming Task (Stackhouse et al., 2007) where the overall score moved from a severe to a mild range of difficulty. However, although her speech had improved overall, persistent glottal replacement and difficulties with fricative production, particularly in SFWF contexts were still evident in multi-word utterances. In all types of utterance minor phonetic differences and timing issues were still in evidence.

Lily continued to have difficulties in oro-motor movements and motor planning, as evidenced by the oro-motor assessment and DDK task and her voice quality remained breathy. She still showed evidence of atypical segmental transitions. She also showed ongoing vulnerability in input processing tasks, particularly those activities involving complex non-word discrimination.

This leads to the exploration of the impact of these changes on Lily's intelligibility as experienced by the listeners who participated in the study.

6.25 Intelligibility T2

Lily's intelligibility at T2 was measured in the same way as at T1 (see Chapter Three, Methods). The same 10 SW and 5 imitated sentences recorded at T1 were recorded again at T2 and edited for the intelligibility task; the conversational speech samples from T2 were obviously different. Results for T1 and T2 were compared (see table 6.13).

Table 6.13 Lily: Intelligibility outcomes T1 compared with T2: Percentage (and number) of items correctly identified

Data type	**T1 Mean % (No.)**	T1 S.D. % (No.)	T1 Min score % (No.)	T1 Max score % (No.)	**T2 Mean % (No.)**	T2 S.D. % (No.)	T2 Min score % (No.)	T2 Max score % (No.)
Single words (max no. = 11)	**23.41 (2.58)**	15.79 (1.73)	0 (0)	15.79 (7)	**85.12 (9.36)**	9.10 (1.00)	54.55 (6)	100 (11)
Imitated sentences	**36.42 (8.74)**	11.23 (2.69)	12.50 (3)	62.50 (15)	**78.21 (18.77)**	10.06 (2.41)	50.00 (12)	95.83 (23)

(max no. = 24)								
Conversational speech (max = 100%)	**40.09**	17.84	3.57	75.00	**86.07**	6.66	69.05	97.62

Analysis of results using the Wilcoxon Signed Ranks Test demonstrated that the listeners' recognition of Lily's single words at T2 (see table 6.14), had improved significantly (Z=-7.090, p<.0001). Results for the imitated sentences also showed significant improvement (see table 6.15) (Z=-7.072, p<.0001) as did conversational speech (see table 6.16) (Z=-7.063, p<.0001). The significant difference between SW and conversational speech demonstrated at T1 was no longer in evidence at T2 (Z=-.042, p<.967). The relationship between imitated sentences and SW at T2 had changed in favour of SW (Z=-4.690, p<.0001). Conversational speech was now better recognised than imitated sentences (Z=-5.074, p<.0001) whereas at T1 there had been no significant difference between them.

The range of listener responses at T2 remained wide for all types of stimuli, for example, one listener (L1) recognised only 6/11 SW and two (L49 and L55) recognised all 11 words. Overall, conversational speech was marginally the most intelligible type of utterance, but the difference between CS and single words was not significant. Although one listener (L9) identified only 69.95% of CS, 2/66 listeners (L25 and L38) identified 97.63% of the utterances.

Table 6.14 Lily: Individual single words from intelligibility task T1 and T2

Word	Adult target	**Lily's realisation T1**	Number of listeners identifyin g word T1	**Lily's realisation T2**	Number of listeners identifyin g word T2
CAR	/kɑ/	[kʰ ɑ̤ː]	51/66	[kʰ ɑ]	51/66
FISH	/fɪʃ/	[fɪ]	11/66	[fɪʔʃ]	66/66
GIRL	/gɜl/	[dɛʊ]	28/66	[gɛʍ]	66/66
PRAM	/præ̃m/	[p̆ æ̤̃n]	0/66	[pʰ ɹæ̃ːm]	66/66
SAUSAGE	/ˈsɒsɪʤ/	[ˈʔɒʔhɪdz̤]	2/66	[ˈsːɒsɪ]	50/66
SCHOOL	/skul/	[d̥əuʍ]	5/66	[sk̬ʼul]	48/66
TIGER	/ˈtaɪgə/	[ˈtʰ ːaɪvə]	17/66	[ˈtʰ a̤ɪgə]	59/66
TOMATOES	/təˈmɑtəʊz /	[ˈmɑ̃ʔəʊ̤]	22/66	[tʰ əˈmɑ̃təʊ(dz̥)]	66/66
TRAIN	/tɹeɪ̃n/	[t̚ eɪ̃n]	32/66	[tɹ̥eɪ̃n]	63/66
VAN	/væ̃n/	[fːæ̤̃n]	2/66	[v̥ːæ̃n]	66/66

Responses to individual items varied. In single words (see table 6.14) at T2 SCHOOL was least intelligible (48/66) whereas five of the words, FISH,, GIRL, PRAM, TOMATOES and VAN were identified by all 66 listeners. In comparison, CAR had been the most intelligible SW at T1 and PRAM the least intelligible. To measure how well MWU were recognised the total number of words in each utterance was multiplied by the number of listeners and the percentage of correctly identified words was calculated (see table 6.15 and 6.16).

Table 6.15 Lily: Individual imitated sentences from intelligibility task T1 and T2

Target sentence	**Lily's realisation T1**	Percentage of words recognised by individual listeners T1	**Lily's realisation T2**	Percentage of words recognised by individual listeners T2
HE (HIM) JUDGED THE COMPETITION	[ɪ˜n ˈd̚ʌʔ də ˈdɒ˜m˘ʔəˈdɪʔə˜..n]	0.76%	[hi ˈʤʌʔ d̥ə ˈkɒ˜ntəˈtɪʃə˜n]	33.71%
HE SNEEZED VERY LOUDLY	[ɪ˜n ˈni..t'̚ wɛwi ˈlaʊd̩li..]	54.24%	[hi ˈsnid̥ʰ vɛɹi ˈlaʊ..dlɪ..ː]	88.48%
JOHN COLLECTS STAMPS	[ˈdɒ˜n dəˈdɛʔ ˈdæ..˜nt]	0.30%	[ˈʤɒ˜n dəˈklɛʔ. s ˈstæ˜mps]	74.55%
MY LEFT LEG HURTS	[mãɪ ˈlɛf ˈɬɛt' ˈɝʔ]	87.27%	[mãɪ ˈlɛf lɛg̚ ˈtɜts]	99.70%
YOU MUST STIR IN THE SUGAR	[ˈjʊ˘ mʌ..ʔ ˈdɜʷ ɪ˜n də ˈʔʊdə..]	32.42%	[ˈju mʌs ˈstɜʴ ɪ˜n və ˈsʊ..gə..]	85.71%

In sentence imitation HE JUDGED THE COMPETITION was least well recognised (33.71%) and MY LEFT LEG HURTS (99.70%) was best; the same as at T1. In conversational speech at T2 the least well recognised utterance was BOBBY WOULD SAY "STOP DAD, STOP DAD, TAKE ONE HOME" (69.0%). The best was BUT WE DIDN'T STAY THAT LONG BECAUSE IT WAS GETTING COLD (98.76%).

6.16 Lily: Analysis of conversational speech samples from intelligibility task T1 and T2

Target sentence	**T1 or T2**	**Lily's realisation**	**Percentage of words identified by individual listeners**
I ACTED AND SINGED	T1	[ʔaɪ.. ˈʔæ..ʔdɪd æ˜n ˈʔɪ˜nɪʔt]	17.42%
IN THE OFFICE AND IN	T1	[ɪ˜n də ˈʔɒ..f˘ːɪʔ ɛ˜n	48.79%

THE HALL		ˈɪ˜n də ˈʔɔ̤ʊ̤]	
ON BOXING DAY I WILL GO TO MY DAD'S	T1	[ʔɒ˜n ˈbɒʔdɪ˜n̥ ˈdeɪʲ aɪ wʊfŋ̩ ˈdəʊ dufŋ maɪ ˈdæʔ]	31.31%
ON THE CHRISTMAS TREE	T1	[ˈʔɒ˜n də ˈdɪʔmə ˈdi]	53.54%
WE MAKED DECORATIONS	T1	[wi̤ ˈmeɪ̤ʔɪd̚ ˈdɛ̤ʔəweɪʔə˜n̥]	66.36%
BECAUSE WE DIDN'T HAVE A TRAILER	T2	[ˈbikə̤d̥ wi ˈdɪdn̩ ˈhæv̩ə ˈtɹḛɪlə̤]	85.45%
BOBBY WOULD SAY, STOP DAD, STOP DAD, TAKE ON HOME	T2	[ˈbɒbi wʊd͡ ˈde̤ɪ ˈstɒp̩ dæd̥ ˈstɒp dæd ˈtʰ eɪx wʌ˜n͡ ˈəʊ˜ːm]	69.09%
BUT WE DIDN'T STAY THAT LONG BECAUSE IT WAS GETTING COLD	T2	[ˈb̥ʌʔ ˈwi dɪdə˜nt ˈsteɪ væʔ ˈlɒ˜ŋ bɪˈkʰ əd ɪʔ wəd̚ ˈɡɛ˜ːŋ ˈk̚ əʊd̥]	98.76%
WE COUNT HOW MANY PEOPLE WAS IN ONE PLACE	T2	[wi ˈkʰ aʊ˜ʔɪ ʔaʊ ˈmɪ˜ni ˈpʰ ipʰ ʊ wɒd ɪ˜n wʌ˜n ˈple̞ɪs]	82.42%
WELL WE WENT TO NEW FOREST	T2	[ˈwɛʊ wi ˈwɛ˜nt̚ t̤su ˈnu ˈfɒ̤ɹɪs]	97.92%

Following the detailed study of Lily's speech output and intelligibility, the research questions were considered in relationship to the findings. The discussion is focused mainly on findings from T1 unless otherwise indicated, apart from section 6.26.6.

6.26 Discussion

The aim of this chapter has been to give a detailed description and analysis of Lily's speech in single words and multi-word utterances, and to consider the impact of her speech production difficulties on her intelligibility as judged by a group of adult listeners. At T1, at the age of 7;2 years, Lily's PCC was 40.90% and on the Picture Naming Task (Stackhouse et al., 2007) she produced only 7/60 whole words (11.66%) that matched adult forms, z=-12.01. On both of these quantitative measures the accuracy of her speech production was well below the level expected of a typical seven-year-old suggesting that her speech was severely impaired. She could therefore be confidently included in that group of children described as having "persisting speech difficulties" (Pascoe et al., 2006).

6.26.1 What will the detailed perceptual phonetic analysis of Lily's speech at word level reveal in terms of a traditional phonological process analysis (PPA)? What features are not captured through a traditional PPA?

6.26.1.1 Phonological process analysis

The examination of Lily's speech first focused on a phonological process analysis, an approach which has been described as essentially one-dimensional in that it provides a quantitative measure of children's speech but with little explanatory power (Ingram & Dubasik, 2011). Process analysis based on both SW and MWU at T1 showed simplification patterns, typically seen in children who have speech delay, affecting both structural and systemic patterns in Lily's speech.

6.26.1.1.1 Structural processes

Structural processes such as cluster reduction and weak syllable deletion are frequently described as occurring in speech delay or disorder (Bradford & Dodd, 1996; Davis et al., 1998; Dodd, Holm, Hua, & Crosbie, 2003). The most common structural process in Lily's speech was cluster reduction.

Lily's consonant clusters in SIWI position were reduced to a single element, and the two examples noted of realisation with two segments were so unusual in her speech at T1 that they could be described as "exceptional forms" (Grunwell, 1987, p. 101). Both instances involved fricative segments (in SNAKE and THREE), so were unlike first clusters usually used in typical development which consist of plosive elements (McLeod, Van Doorn, & Reed, 2001). However, there were examples of SFWF clusters and the use of these before the development of more complex SIWI onsets mirrors what has been described in typical speech, albeit at a much later stage than expected. It has been argued that the development of these complex coda sequences may be partly driven by the emergence of grammatical morphemes (McLeod et al., 2001). Lily was not generally using the regular past tense morpheme or plurals but they occurred occasionally as when she realised the complex SFWF sequence in JUMPED [dʌ̃mpt] and also a SFWF alveolar fricative to signal a plural as in LEGS [lɛg̊ts̬]. The presence of a nasal element in the cluster may have facilitated her output of more complex coda sequences as in NAMES [nɛ̃ɪ̤md̥ː] because SFWF nasal segments were usually realised is a typical form.

Lily's SIWI and SIWW consonant clusters followed predictable patterns as described in section 6.10.1.1. Her consonant to vowel transitions in clusters were affected by the same difficulties as other consonant to vowel transitions, for example, FLOWER realised as [ˈfːaʊ̤wə̤] and voicing of unvoiced segments such as PLAYER realised as [ˈbeɪjə̤]. However, the most striking feature was the extreme simplification of her cluster realisations and the significant constraints on word structure that this imposed (Velleman, 2002), impacting negatively on intelligibility (Hodson, 2006; Hodson & Paden, 1981).

6.26.1.1.2 Systemic processes

Lily presented with common systemic processes such as glottal stop realisations and velar fronting (Bowen, 2009; Grunwell, 1987; Wolk & Meisler, 1998).

Lily's speech showed frequent use of glottal stops for obstruent consonants in all word positions. This included a pattern of glottal replacement for SIWI and SIWW alveolar and post-alveolar fricatives. These particular data present with some difficulties in analysis and classification, particularly with their occurrence in the onset position.

One viewpoint would suggest that the glottal stop represents a replacement segment for the fricative target. Grunwell (1987) describes glottal stop replacement as "an extreme form of simplification" (p. 240) and indeed it may be a clinical marker for speech difficulties or delay in young children (Bowen, 2009) when used to replace segments other than those such as /t/ predicted by the child's linguistic environment. When considering the SIWI examples, and taking another perspective, it is possible that Lily was entirely deleting the onset segment and that the glottal stop represented the phenomenon of glottal stop onset preceding SIWI vowels seen in typical speakers (Redi & Shattuck-Hufnagel, 2001). The process of initial consonant deletion (ICD) has been called "non-natural" (Shriberg, 1997, p. 124) and "one of the most common atypical processes" (Stoel-Gammon, Stone-Goldman, & Glaspey, 2002, p. 6). Hodson and Paden (1981) in their study of a group of children who had unintelligible speech reported that the least intelligible almost all had "one or two" (p. 371) unusual features. ICD may have particularly impacted on Lily's poor intelligibility because of its effect on word structure (Velleman, 2002).

For the purposes of classification in traditional phonological process analysis these two different perspectives present a dilemma; the realisation of adult targets as glottal stops would be categorised as a systemic process, (although depending on its place in a word, it may also be structural as when replacing a consonant cluster, Grunwell, 1987) and ICD as a structural process (Velleman, 2002). From a clinical perspective these contrasting interpretations of the presenting output would potentially impact on target setting for intervention since it is recommended that structural processes are a focus before systemic ones (Hodson & Paden, 1991; Hodson, 2006). If Lily was replacing a fricative with a glottal stop this would imply that her underlying representation for the target word included the presence of an onset consonant. The fact that she also used glottal stops for SIWW fricative targets suggested that the difficulties could be categorised as systemic rather than structural, i.e. glottal stop use in the within-word position implies target replacement rather than omission. However, a more useful alternative may be to consider this difficulty in the context of Lily's significant articulatory and motor constraints. This explanation suggests that glottal replacement represents a solution to her inability to produce fricatives easily, particularly in managing transitions between a fricative consonants and the following vowel, and possibly in transitions at word boundaries more generally. This is explored further in the next section (6.26.1.2).

Lily's production of velar plosives showed some variation with approximately half of all SIWI/SIWW and the majority of SFWF/SFWW targets in SW realised in the adult form; in MWU the majority were perceived as alveolar plosives or glottal stops in coda positions. A question is raised about the source of this variation. Data from EPG studies have established that there may be a mismatch between the auditory perception of children's speech (and what is therefore transcribed) and findings from instrumental analysis concerning tongue movements (Howard, 2001; Howard & Heselwood, 2011). Gibbon (1999) reviewed the literature that examined use of EPG to monitor tongue placement for alveolar and velar plosives in speech with 17 children aged 5 to 12-years-old who had articulatory/phonological difficulties. Her review concluded that 12 of the 17 had "undifferentiated gestures" (Gibbon, 1999, p. 388) which showed "simultaneous anterior and posterior contact of the tongue across the palate" (Rvachew & Brosseau-Lapre, 2012, p. 561). The poor differentiation of tongue movement reflects difficulties with the motor skills required for speech production. It is possible that Lily's more or less adult-like realisations were due to motor planning difficulties rather than lingual motor movements *per se*. However, it is also possible that the apparent variation in Lily's production of plosives has a perceptual basis. She may have made an imperceptible but consistent place of articulation contrast with the tongue dorsum articulation against two different points on the hard palate, rather than making the typical alveolar-velar place of articulation contrast using tongue tip versus tongue dorsum. The listener's perception could then be affected by the phonetic context of the target segment or by listener expectation (Ollers & Eilers, 1975). Although in the absence of EPG data for Lily this argument can only be speculative, Howard (1998) makes an observation that may lend support for articulatory limitations rather than motor planning constraints. She comments that EPG data, based on the physiological and phonetic evidence for the importance of viewing the tongue as comprising independent sub-systems, suggest that children who have difficulty with tongue tip or blade gestures may have no such difficulties with movements involving the tongue body. Gibbon (1999) observes that

> "increased tongue body activity observed in undifferentiated gestures might be strategy to compensate for a tongue tip/blade system that lacks fine force control" (p. 395)

It may be recalled that the results of Lily's oro-motor assessment (section 6.6) indicated that she was unable to elevate her tongue tip in imitation or to command. Whilst the framework of phonological process analysis offers one explanation of Lily's alveolar and velar contrasts, this articulatory/gestural viewpoint may offer a viable alternative.

The articulatory/gestural approach might also provide a framework for the conceptualisation of Lily's vowel production. There was some small evidence of consonant-vowel interactions, with alveolar plosives influencing the realisation of an adjacent vowel These might be explained as an effect of coarticulation, with an overlap between the consonant and vowel gestures (Bates et al., 2013). These patterns have been reported in very young typically developing children and the interactions between segments are most likely to occur when the place of articulation for the targets are in close proximity (*ibid*). Their occurrence in Lily's speech is indicative of a speech processing system that is extremely immature and/or impaired. The occasional apparently idiosyncratic realisations can best be explained as gestural mistiming, again in the context of a system that is highly constrained where processing load (as in the sentence imitation task) has unexpected consequences.

6.26.1.2 Features not captured through phonological process analysis

Although Lily had a severely restricted structural and segmental system, it was her slow and effortful transitions between segments, syllables and words with the concomitant impact on duration at sound, word and utterance level which made her speech so unusual.

Hodson and Jardine (2009) comment that "small variations in timing can have dramatic effects on intelligibility" (p. 127). Furthermore, her voice quality was frequently breathy which may not have affected her intelligibility but added to the overall impression of "difference" in speech production.

It may be helpful to consider Lily's speech patterns in relation to the articulatory or gestural approach to phonology, (Browman & Goldstein, 1992). Bybee (2001) says that:

> "A typical utterance is composed of multiple gestures overlapping or sequenced with respect to one another. An individual gesture is produced by groups of muscles that act in concert, sometimes ranging over more than one articulator" (p. 69)

In Lily's speech there was little sense of articulators acting "in concert" (Bybee, 2001) and her speech did not show predictable and uniformly smooth transitions and coarticulation at syllable, word or multi-word utterance level. The perceptual impact of this was that she had difficulty in, for example, coordinating the transition between the onset fricative and vowel in the word VAN realised as [fːæ̤˜n]. This process which involves a reduction of the coordination of movement from one segment to the next is referred to by Kent (1992a) as "segmentalization". In effect the speech pattern has "the appearance of having been 'pulled apart' or separated" (p. 262). This separation was also recorded in two syllable words between syllables with a resulting disruption to stress patterns, as in BROTHER [ˈbʌ(.)ˈdʌ] and OUTSIDE [ˈʔəʊ(.)ˈʔaɪd]. These phenomena have been reported as occurring in dyspraxia (although in an adult population, with acquired motor speech disorders, Liss & Weismer, 1992) where the occurrence is characterised by variability. This was the case in Lily's speech where, for example SIWI /f/ was realised with a relatively long onset fricative in FOOT [fːuʔ] but in FISH was realised in a typical manner as [fɪ]. The disruptions at syllable and word level characteristic of Lily's speech may have their origins in "problems in planning and programming of speech movements [which] leave their traces in the coarticulatory cohesion of utterances" (Nijland, Maassen, van de Meulen et al., 2002, p. 463).

Although Lily's speech output was atypical and sounded effortful, her attempts to produce fricatives (including morphological markers) suggested that she did have established underlying phonological representations for those targets. Therefore, it can be hypothesised that motor and articulatory constraints were major factors in word production. This is not to suggest that she had entirely typical underlying representations but that her difficulties were more clearly evidenced in output skills (see section 6.26.4).

Lily's restricted and reduced segmental patterns, especially in multi-word utterances suggested problems in sustaining articulatory power. Harris and Cottam (1985) describe a model similar to that of Browman and Goldstein (1992) that conceptualises production of segments in terms of two stages, the first is the glottal gesture, the second the supraglottal gesture which relates to the "degree of stricture in the oral cavity" (p. 68). They describe the very different speech patterns of two children in terms of their difficulties in sustaining articulatory strength, with glottal replacement or consonant deletions representing the most extreme forms of lenition. Interactions between physiological and phonetic features and the phonological system are explored, for example with one child, the loss of word final contrasts due to the glottal replacement of SFWF obstruents.

Harris & Cottam's (1985) account has a resonance with Lily's speech patterns. As already described, her realisation of alveolar and post-alveolar fricatives was frequently a glottal stop in onset, coda and within-word positions, for example, SEESAW [ˈʔiʔɔ]; PARACHUTE [ˈp̚ æwəʔṳʔ]; DINOSAUR [ˈdaɪ̃nəʔɔ̤ː]; MOUSE [maʊ̤ʔ]. This corresponds with the extreme form of lenition reported in the Harris and Cottam study. However, there was also evidence of alveolar and post-alveolar fricatives being realised as plosives, for example, SCISSORS [ˈʔɪʔd̥əd̥]; HOUSE [haʊːptʰ]. This process represents the exact opposite of lenition because plosives are the segments requiring most fortition (Ball, 2003). The realisation of fricatives as plosives (apart from glottal stops) was not frequent at T1 but subsequently emerged as a target for intervention; it is interesting to speculate whether these occurrences represented a progressive change in Lily's speech. Theoretically, producing plosive consonants for fricative targets could be the result of difficulties in managing to control the degree of constriction needed for fricative production (so called "scaling" Kent, 1992a, p. 259) or fine force movements (Hodson & Jardine, 2009). Fine force movements, as the name suggests, involve precision of motor movement and contrast with the rapid and forceful ballistic movements required for plosive production. There may be an unfolding progression for Lily from having some difficulties in sustaining articulatory force and so having a pattern of glottal replacement to then judging and managing the production of the degree of constriction needed, resulting in stopping of fricatives, to then, by T2, having achieved the necessary motor control skills to realise the full range of speech sounds.

One further impact of Lily's motor difficulties was on her voice quality which was atypically breathy and dysphonic. Breathy voice quality can be described as part of a continuum, with creaky voice and breathy voice at either 'end' of modal (the typical range for speaking) voice quality (Epstein, 2002). Judgements of voice quality are based on the auditory perceptions of the listener (Gerratt & Kreiman, 2001) but there are difficulties in establishing methods for reliable consensus agreements for these judgements (Odell & Shriberg, 2001). Breathiness appears to present particular challenges since as described by Gerratt and Kreiman (2001) even achieving listener agreement that breathiness is present is difficult "except in cases where the voice is nearly aphonic" (p. 337). The production of breathy voice is typically described as being produced with "relaxed and incomplete closure of the vocal folds" (Epstein, 2002, p. 1) giving "the impression of turbulent noise and audible escape of air through the glottis due to insufficient closure" (Gerratt & Kreiman, 2001, p. 377). However, as Gerratt and Kreiman (2001) point out, speakers with wide opening of the glottis may not sound breathy and those with little turbulence may do, with many physiological and perceptual variables occurring. In the course of this study it was noticeable that when Lily had an upper respiratory tract infection she became almost completely aphonic; unsurprisingly inflammation of the vocal tract worsened the effectiveness of vocal fold oscillation.

There is a paucity of literature reporting studies of voice in children (Benninger, 2011) and even fewer reports on voice in children who have other speech and language difficulties. For example, the ALSPAC study which has reported extensively on PSD (Wren, Roulstone, & Miller, 2012; Wren, McLeod, White, Miller, & Roulstone, 2012) also reported the prevalence of childhood dysphonia in the same population to be around 6% (Carding, Roulstone, Northstone, & Team, 2006). However, neither study to date has reported on any cross-over between the two groups. It is therefore difficult to know whether, as a child with PSD, Lily's voice difficulties are unusual or not. Voice quality differences in children who speech difficulties have been associated with CAS and dysarthria, i.e. motor speech disorders, but not with speech delay or persisting speech difficulties (Shriberg, Lohmeier, Strand, & Jakielski, 2012). However, Reynolds (2002) described atypical voice quality in two children who had phonological disorders, and suggested that this was related to difficulties in laryngeal control. There may also be an effect of poor coordination or respiratory control on voice quality (Cohen, Wardrop, Wynne, Kubba, & McCartney, 2012). As already described, Lily's performance on both oro-motor and DDK tasks (see section 6.6) had suggested that she had difficulties both in power and precision of oro-motor movements and motor planning difficulties. It appeared these difficulties in fine motor control impacted at a laryngeal level resulting in a noticeably breathy voice quality. The perceptual effect of this breathiness when combined with Lily's atypical segmental durations was that the overall quality of her speech production was significantly different to that of her peer group.

6.26.2 What does comparison of the patterns in Lily's speech data reveal across three speech elicitation conditions (1: single word production; 2: connected speech in sentence imitation; 3: connected speech in spontaneous conversation)

Comparison of Lily's speech output across the three sampling conditions shows limited examples of systemic segmental differences predictable by sample type. An exception was the realisation of velar plosives. These were consistently more accurate in SW than in MWU. In MWU in SIWI positions they were usually fronted, and in SFWF positions they were usually realised as a glottal stop. It has been reported that the position of segments in a word may change their realisation (Holm et al., 2007). However, variability in one target segment or even position in a word does not predict variability in another, and it may not be unusual to find that individual segments are subject to different levels of consistency (Tyler, Williams, & Lewis, 2006). Greater accuracy in single words for particular processes might be predicted on the basis of the processing load being less than for MWU (Howard, 2007), supporting the realisation of newly-established speech sounds, although overall the findings about accuracy in SW and MWU are not unambiguous. Wolk and Meisler (1998) found a higher rate of phonological process occurrence in SW than in conversational speech whereas other studies report greater accuracy in SW, particularly in word structure (Faircloth & Faircloth, 1970; Masterson et al., 2005). The Wolk and Meisler (1998) study may reflect that the SW assessment included structures and segments which the children did not use in conversational speech, thus quantitative analysis of MWU may under-report severity in some children. For Lily, the extreme simplification evident in all sample types meant that comparison did not obviously reveal differences such as those reported in published studies.

Although there were few examples of predictable segmental differences between SW and MWU, there were contextual phonetic effects and these related to the position of the target in an utterance, notably the production of SFWF fricatives at the end of a word or an utterance or, very occasionally, within an utterance before a pause. There were two examples in single words and three in MWU. Two of these in MWU occurred in utterance-final position and were plural morphemes and one was a possessive morpheme within an utterance (see section 6.12.2). Their realisation all preceded a pause, which suggested that Lily's production of these SFWF consonant clusters was facilitated by a simplified phonetic environment. The space or "external open juncture" (Heselwood, Bray, & Crookston, 1995, p. 127) created by not having to simultaneously plan the next part of an utterance may allow for the realisation of more complex segmental sequences. This adds support to the view that output constraints in terms of motor planning difficulties significantly impacted on Lily's speech output. If the difficulty was in establishing underlying representations of these lexical items, the phonetic context would not be expected to make a difference to their production.

The inclusion of the different types of sampling conditions revealed phonetic, phonological and prosodic information which was not evident from the SW data alone. The sentence imitation task showed that Lily was using assimilation and liaison and there were examples of liaison in conversational speech. However, she did not use common word juncture processes as frequently as typical peers. Analysis showed that there were examples of her using typical articulatory reduction and close juncture in high frequency utterances, but her multi-word utterances were more often characterised by open juncture with frequent insertion of glottal stops or pauses at word boundaries. Lily's inconsistent use of between-word processes and pervasive use of glottal stops at word boundaries show similarities to a child, Sam, described by Howard (2007). Sam's speech rate was described as slow with frequent pauses and, like Lily, on occasion he realised two syllable words with equal stress. Also like Lily, Sam was able to produce adult-like close juncture but his realisations were also subject to variability impacting on the syntagmatic fluency of his speech output.

It has been suggested that children with typical speech development may approach word juncture behaviours in two different ways (Howard, Wells, & Local, 2008). Some children have an analytical, bottom-up approach to language learning with shorter utterances produced more clearly and with open juncture and some have a gestalt approach, with long and fluent utterances which have close juncture but poor intelligibility (Peters, 1977; Wray, 2002), and some may use both. It is not entirely certain if there are developmental trends in the use of open and close juncture but studies of young typically developing children suggest that this may the case (Newton & Wells, 2002; Thompson & Howard, 2007). These studies suggest that children learn how to manage word boundaries over time. There is a further suggestion that children may be sensitive to the pragmatic aspects of particular linguistic situations, in that the young child studied by Peters (1977) approached naming tasks, such as looking at a book with an adult, with much more carefully articulated output than in free play where he was very vocal but unintelligible. Both hyperelision and hyperarticulation have been reported in children who have speech difficulties (Faircloth & Faircloth, 1975; Howard, 2007; Wells, 1994), sometimes occurring in the speech of the same child, and even the same utterance. This is not unexpected because typical speakers also vary in the degree of articulatory reduction employed in ways which are predictably linked to the rapidly changing demands and requirements of any given communication situation (Shockey, 2003). However, if it is the case that children have a preferred style, and if like Lily there are significant problems in speech production, a question is raised about the interactions between individual preferences and system constraints. An example relevant to this point is explored by Howard (2013) in relation to the speech of two children who have cleft palate. The speech production of one child, SB, was characterised by open juncture and few examples of connected speech processes. SB was described as "prioritizing paradigmatic accuracy over syntagmatic fluency" (p. 219) but his speech presented as prosodically atypical. Although Lily was not at the stage of having "paradigmatic accuracy" because of her constrained segmental system, her preferred style nevertheless appeared like that of SB. Her multi-word utterances were significantly more intelligible than her single words, but the unusual prosody of her speech impacted negatively on its acceptability, where acceptability is defined as the subjective rating of speech by listeners in terms of "bizarreness, naturalness or normalcy" (Dagenais & Wilson, 2002, p. 364), (a direct contrast to Harry in Chapter Five). McLeod (2012) states that "currently there is no metric for determining speech acceptablility" (p. 122); assessment is dependent on the contextual judgement of the listener, a point made also by Howard (2013).

6.26.3 Does Lily's speech output show phonetic variability within different speech elicitation conditions?

Lily did show variability in her speech and although token-to-token differences were not frequent, they did occur both in single words and in multi-word utterances. Her variable production was more evident at a segmental level, i.e. particular segments were realised inconsistently in terms of articulatory place and manner. Segmental production also varied in transitions between consonants and vowels, and it was not possible to predict with any certainty how transitions would be realised.

Variability is characteristic of early speech development (Marquardt, Jacks, & Davis, 2004) and reduction in variability becomes evident as the speech system matures and becomes more automatic (Nijland et al., 2002). If variability is a product of an immature speech processing system, the source of Lily's inconsistencies may be traced to her overall processing difficulties (see section 6.26.4). However, although variation in token-to-token and segmental output might be the result of, for example, updating motor programmes (Pascoe et al., 2006), it was possible that variability in managing transitions was a reflection of difficulties in motor planning or motor execution.

6.26.4 Does the psycholinguistic speech processing profile provide explanations of Lily's speech output patterns?

Lily's psycholinguistic processing profile indicated that she had difficulties with both input and output skills but her task performance showed differences which may be relevant in an explanation of her speech patterns. Lily's discrimination of both real words and non-words was impaired in comparison to a group typical 7-year-olds. Although non-word scores were poorer than real word scores, both sets of results were significantly below the expected level. However, Lily's age-appropriate score for the auditory lexical decision (ALD) task suggested that her phonological representations were accurate (Stackhouse & Wells, 1997). The performance differences between the discrimination and ALD tasks suggested that Lily's phonological working memory may have been a factor; she was able to recognise whether a heard word was being said with accuracy, but found it more challenging to hear two words and make a reliable judgement. The fact that the real word discrimination was better that the non-word score demonstrates that top-down processing aided her management of the task by providing support from already established lexical knowledge. Even with this assistance, her real word score was impaired in comparison with the scores of typical peers. One interpretation is that Lily's phonological working memory was reduced. However, Couture and McCauley (2000) suggest that children with phonological impairment do not have difficulty in short-term phonological memory or sub-vocal rehearsal. Instead, based on their own work, and that of Gathercole and Martin

(1996), they postulate that performance on phonological tasks requiring skills in immediate recall are dependent on long-term memory, to draw upon already stored phonological knowledge in order to successfully carry out what is required. In order to carry out the discrimination between two words as presented in the assessment tasks Lily needed to hold them in short-term memory and judge their phonetic similarity (or difference). Discrimination activities involving right/wrong or minimal pair judgements based on pictures may offer more direct insight into the accuracy of phonological representations, and the child's recognition of speech sound similarities and differences, by reducing the memory loading of tasks. The disadvantage of this approach is that it does not allow for the assessment of speech sound perception without support from previously stored information. The use of non-lexical items in assessment gives insight into children's ability to discriminate speech sounds with novel words which has implications for learning the sound patterns and meaning of new vocabulary.

Lily's output processing was significantly impaired with severe difficulties at every level of the profile. Her performance on assessment tasks showed that her output was subject to similar constraints at every level. Lily's poor DDK rates and accuracy, and aspects of her speech output which indicated difficulties with motor planning and performance suggested that these constraints could be articulatory as explored in section 6.26.1.2. In this respect her profile is almost the same as Hamish's; this is discussed in Chapter Seven, section 7.26.4. As with Hamish, Lily's profile provided a summary of the complexities of her processing difficulties and highlighted their diffuse nature. Until this study was carried out Lily had had no investigation of her input processing skills. She had participated in groups designed to promote phonological awareness skills but these were not based on any specific or individual targets designed to increase her perception skills (which had anyway not been assessed). The profile also provided a framework for intervention planning (Stackhouse et al., 2006) which was focused on Lily's particular needs.

6.26.5 Does the intelligibility of Lily's speech vary across different speech elicitation conditions?

Listeners' recognition of Lily's speech was severely impaired, but words in conversational speech and imitated sentences were better identified than single words. This relationship between the relative intelligibility of SW and connected speech has been previously reported (McGarr, 1983; Osberger, 1992; Speake et al., 2012). Listeners' word recognition is aided by the additional contextual, syntactic and phonological information available in sentence level utterances, as well as prosodic factors such as appropriate use of intonation (Klopfenstein, 2009). However, these findings are not unequivocal and factors such as the familiarity of vocabulary and grammatical complexity may increase or decrease successful identification in MWU. Speakers who have the most severe speech difficulties may be equally unintelligible in all contexts (Sitler, Schiavetti, & Metz, 1983).

On the basis of the severity of Lily's speech difficulties as measured, for example, by PCC and z-scores on naming and imitation tasks, recognition of all types of utterance may have been similarly impaired. The reasons why this was not the case are largely speculative, although the methodological bias regarding the selection of conversational speech recognisable by the author, discussed in Chapter Three, Methods, must be one factor. This would not, however, explain the relationship between SW and imitated sentences in favour again of MWU. It appeared that listeners were aided by the additional cues available at sentence level even when challenged by the phonetically highly degraded content of Lily's speech.

One further observation of Lily's intelligibility was that all types of utterance showed a wide range of listener responses. For example, the responses to Lily's conversational speech ranged from 3.57% to 75.00% of words recognised. Khwaileh and Flipsen (2010) suggest that the measurement of intelligibility of both SW and sentence level utterances are enhanced by considering the range of responses, giving a greater understanding of the individual child's communicative potential. This also captures the experience of individual listeners, although it was not the case that any one listener performed, for example, at the top of the range across all three types of stimuli.

6.26.6 Are any changes in Lily's speech output evident between two points in time and do any changes impact on the intelligibility of her speech?

Lily's speech changed significantly between T1 and T2 with the quantitative changes described in section 6.19, including for example PCC of just over 90%, reflecting improvements in both structural and systemic realisations. Examination of the differences between the two time points revealed the establishment of mature patterns of consonant clusters, fricatives, affricates and the post alveolar approximant [ɹ]. However, Lily's speech continued to show evidence of minor phonetic differences and timing issues both in single words and in multi-word utterances. Her speech output was not particularly reflective of the descriptions in the literature as characteristic of persisting speech difficulties such as realisations of /s/ and /r/ (Shriberg et al., 1997b). Instead she showed variable occurrences of the types of segmental and prosodic patterns she had shown at T1. These patterns continued to be underpinned by motor difficulties, as evidenced by the DDK and oro-motor tasks which had not changed at all. One further change noted was in Lily's use of word juncture. In the 20 months between T1 and T2 her between-word processes had become much more adult-like with the use of open and close juncture showing more typical patterns.

The changes to Lily's speech were predicted to positively impact on what listeners recognised since, amongst other factors, intelligibility is linked with the "degree of articulatory precision in producing segmental phonetic contrasts" (Bradlow, Torretta, & Pisoni, 1996, p. 13). This proved to be the case with significant improvement across all sampling types. Moreover, the difference between SW and conversational speech which had favoured CS at T1 had resolved, with imitated sentences now showing the lowest mean score. The continuing wide range of listeners' responses, a finding common in the literature (Speake et al. , 2012; Whitehill, Gotzke, & Hodge, 2011), was a reflection of the persistence of Lily's output difficulties.

6.27 Summary and conclusions

A comprehensive phonological process analysis (PPA) of Lily's speech identified a range of processes, some of which were typical for delayed speech, for example cluster reduction and velar plosive fronting, and also atypical patterns (for example, glottal replacement of SIWI and SIWW fricative targets). However, a broader analysis beyond the scope of typical PPA revealed other segmental and prosodic features; the investigation of MWU was effective in showing elements which were not evident from a traditional single word naming test. The conclusion that PPA alone was not sufficient to describe the speech output of children with PSD had also been reached through exploration of Tallulah and Harry's speech output. Lily's MWU showed a preference for open juncture at word boundaries although there were more frequent examples of liaison in the Connected Speech Processes task than shown by Tallulah or Harry. Like Harry, glottal stops and pauses were characteristic of her speech but unlike him she only rarely showed hyperelision in conversational speech. Her speech showed variability with more or less mature realisations of adult targets at lexical and segmental level and also in prosodic aspects such as the duration of transitions between consonants and vowels. This impacted on the acceptability as well as the intelligibility of her speech and this was quite different to the patterns shown by Tallulah and Harry.

Psycholinguistic assessment revealed that Lily's speech processing skills showed some impairment in input tasks and, like Harry she had more difficulty in activities involving non-words than real words. Her difficulties in output tasks were severe and comparison with normed data indicated that her speech production was more impaired than that both of Tallulah and Harry. Lily's speech patterns were similar in non-word repetition and picture naming, suggesting that articulatory constraints affected all types of speech output. A similar finding was reported for Harry, and like Harry, Lily's performance on a DDK task indicated difficulties in motor planning; there was also evidence of poor power and precision in oro-motor movements.

Lily presented with severe and persisting speech difficulties at T1 which affected the intelligibility of her speech in all types of utterance although listeners were better able to recognise words in MWU than as single items. This profile of listener responses was similar to that of Tallulah.

By T2, Lily's speech output and her intelligibility had significantly improved although she continued to show residual difficulties reflecting those identified at T1. This was the same pattern as that shown by Tallulah and Harry.

The next case study in Chapter Seven is Hamish who was 6;7 at the time of the first assessment; this is the first chapter of volume II.