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GOOD COMMUNICATORS, POOR SPEAKERS

An exploration of low speech intelligibility and phonological impairment in children and young adults with Down syndrome

by

Clothra Ní Cholmáin

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SUMMARY

These studies investigated phonological impairment in 75 children and young adults with Down syndrome (DS) who presented clinically with low speech intelligibility. The first study compared intelligibility levels and phonological development in this group with 75 typically developing children (TD) matched by language age. Comparisons were made between the groups using measures of intelligibility levels, phoneme inventories, percentage of consonants correct and phonological processes. The results indicated that the group with Down syndrome scored significantly lower on all measures of the speech system than the language age-matched typically developing group.

The second study explored the phonological systems of 40 participants from the Down syndrome group in greater detail and examined associations between phonological impairment and development in other components of language. This study used rating scales based on constraint rankings from Optimality Theory along with the measures used in the first study to evaluate phonological development and impairment. The British Picture Vocabulary Scale (Dunn, Dunn, Whetton & Pintillie, 1982) was used to establish developmental levels in receptive vocabulary. Subtests from the Test of Auditory Comprehension of Language (Carrow-Woolfolk, 1985) measured receptive morphology and syntax. A speech sample obtained using the Renfrew Action Picture Test (Renfrew, 1989) was used to rate expressive vocabulary, morphology and syntax. Findings indicated significant associations between low speech intelligibility and the phonological system. Associations between phonology and other components of language were also identified.

The third study used the same measures to explore changes in speech and language over time. The findings of this study indicated accelerated orderly developmental change in phonology accompanied by significant increases in language and intelligibility.

The findings were explored using frameworks from studies of language variation and change as well as those currently applied to studies of speech impairment in children and adults with Down syndrome. Implications for clinical practice and research are discussed.

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Introduction

Many children, adolescents and adults with Down syndrome are good communicators but poor speakers. They experience constraints in learning and using speech as an efficient and effective tool for interpersonal communication. Low speech intelligibility presents a major barrier to integration in the educational, social and vocational life of the community.

When listeners encounter speakers with low speech intelligibility they are faced with choices as to

- how they perceive them as people
- how they perceive them as speakers,
- how they perceive their communication systems

Decisions taken determine how both the individual and their language system are classified. Such decisions are not solely based on linguistic variation but call on social, political and psychological value systems.

Speakers with impaired communication systems have in the past been perceived as incompetent members of society and their communication systems have been classified as corrupted or simplified versions of the majority language. They shared this judgment with speakers of pidgins, creoles and minority languages. The recognition of social, cultural and linguistic diversity during the past two decades has fostered an environment where there is increased recognition that differences in speech as a channel for language do not reflect underlying language and cognitive potential. This recognition has been slower to permeate studies of speech impairment in those with learning difficulties (intellectual impairment) and in particular, in those where learning difficulties are associated with Down syndrome.

The low speech intelligibility level associated with Down syndrome has been attributed to many different causes including genotype, cognitive limitations, muscular hypotonia, reduced sensory functioning, reduced inhibitory abilities, slow maturation of the neurological system, deviant neurological development, learning impairment and distorted parent-child interactions. The resulting language end state has been described as delayed, disordered, defective, immature and impaired.

Studies of speech intelligibility and phonological impairment in children and adults with Down syndrome indicate that they share many linguistic features and organisation rules with those of the ambient language but that low intelligibility remains a constraint on the use of speech in interpersonal communication. This impairment has been described in terms of delays, deficits and differences and frequently attributed to immature cognitive structures. The current study was undertaken to identify additional features and patterns of phonological organisation within the language system which could contribute to the persisting low speech intelligibility experienced by many with the syndrome.

CHAPTER 1

GOOD COMMUNICATORS, POOR SPEAKERS

'Good communicator, poor speaker' is a comment frequently heard at public debates and political meetings. It usually refers to a speaker who communicates a strong factual or affective message effectively in spite of variable volume, atypical word and sentence stress patterns, incomplete sentences or leapfrog narrative structures. 'Good communicator, poor speaker' is also a comment frequently heard by speech and language therapists from parents and teachers of children and adults with Down syndrome. In these instances, what is being referred to is that, while comprehension of language appears adequate, speech as a channel for expressive verbal communication fails to match the native language code. This chapter will define the components of speech and language and outline the main theories, frameworks and models currently used to explain why some people are good communicators but poor speakers.

1.2 Communication, Language and Speech

Human communication - the transfer of information between people, has been made possible by the development by societies of shared codes of meaning through language. The nature, structure and functioning of language has been explored from a variety of perspectives by many disciplines including philosophers, linguistics, psychologists and sociologists. Definitions of language abound but show little agreement within or across disciplines, synchronically or diachronically. Speech and language therapists explore language in order to identify and explain impairments in interpersonal verbal communication.

Language, for this purpose, may be defined as the representational system which develops and sustains verbal communication.

Language enables world knowledge to be coded, retained, recalled, and used to achieve satisfactory social interactions. Language uses many channels to interact with internal cognitive structures and with the external environment. Verbal language is the most versatile and hence the most widely used code in human society. It enables speakers to share their knowledge, past experiences and aspirations for the future with their peers in dialogues unrestricted by constraints of time or place. Effective verbal communication is dependent on shared knowledge, of the world, of the linguistic rules to encode this knowledge, and of how to use those rules to convey meaning effectively in various situations. The development of speech, the vocal motor channel for expressing a language, is dependent on experiences of interpersonal communication, on the development of a language system and the development of the vocal motor channel for transmitting language.

Verbal communication - components

Communicative competence is dependent on the integration of three sub domains of language (Bloom & Lahey, 1978). Language **CONTENT** encodes world knowledge into abstract semantic representations, **FORM** provides the rules to allow these representations to be coded for communication and the rules of **USE** determine how language is used to achieve effective interpersonal communication. The key component systems within these sub domains of language of relevance to this study are semantics, phonology, morphology, syntax, and pragmatics.

Content

Semantics operate within language content to determine meaning in language at both word (lexical semantics) and sentence (relational or propostional semantics) levels. The lexicon or vocabulary represents the words available to speakers / listeners for use in communication.

Form

The form of spoken language is governed by the limitations of the acoustic articulatory speech channel and the rules imposed on its use by the members of a linguistic community. The relationships between sound and meaning in language are arbitrary and specific languages are dependent on form to provide rules to connect sounds with meaning. Form governs the selection of sounds and sound combinations to function symbolically in the language through the phonological morphological and syntactic subsystems.

a. Phonology

The phonological system governs the use of sound contrasts to signal meaning in a language. The sounds of speech can be described phonetically with a focus on articulatory or acoustic detail or phonologically where the focus is on speech sounds as abstract representations used to convey meaning in a verbal language system. Both approaches are required in diagnostic and therapeutic approaches to those who present clinically with low speech intelligibility.

Phonetics provides detailed descriptions of the articulatory and acoustic properties of speech sounds. These properties can distinguish developing, mature and atypical phonological systems descriptively. The influence of phonetic properties of speech is being increasingly recognised in theories of phonology. Theories such as Optimality Theory incorporate phonetic markedness (Bernhardt & Stemberger, 1998; Hayes, 1999a,b; Prince & Smolensky 1993) while Functional Phonology recognises the influence of both acoustic and articulatory factors on the developing and mature phonological systems (Boersma, 1998, 2000). These phonetic properties were of limited importance to formalist linguistic theories, which sought to identify abstractions and the underlying rules of speech.

Formalist approaches to phonology focus on speech sounds as abstract units in the language system. Their focus is on the identification of the rules that transform the underlying representations of language into the surface forms of

speech. Phonology identifies the inventory of phonemes - sounds that function contrastively - in the language and the phonotactic rules that govern the sequencing of sounds to make syllables and words. Supra segmental phonology explores the phonetic elements of pitch, loudness, duration, rhythm and silence and the associated prosodic systems of intonation, stress, and rhythm. These prosodic systems function to change or modify meanings within utterance structures.

b. Morphology

The morphological system governs the structure and form of words and operates the rules that regulate how words are modified to change meaning.

c. Syntax

The syntactic system operates rules that govern how words are combined to form phrases, clauses and sentences and larger units of speech.

Use

Pragmatics rules determine how language is used in interpersonal communication across a range of social contexts. Pragmatics rules are called on to select the optimal vocabulary and form to accomplish social goals. The pragmatic rules of language interact with knowledge and rules grounded in social context and culture to achieve optimal interpersonal communication across a range of social situations.

Effective spoken language is the product of a combination of the above components of language working together in both speaker and listener to facilitate communication. Shared semantic knowledge and pragmatic skills allow communication at many levels but effective verbal communication is dependent on the speaker's ability to code the message in the appropriate form and on the

listener's ability to interpret meaning. Speakers adapt and modify the rules of phonology, morphology and syntax to achieve effective communication across a range of social contexts. Languages tolerate a wide range of variation in form without loss of communication efficacy.

The efficacy of speech - the vocal motor channel for expressing a language- has been studied primarily within the phonological sub-domain of language form. Intelligible speech is dependent on the use of an agreed inventory of sounds and on the application of community rules to govern the sequencing of sounds to form syllables and words. Speech intelligibility is also influenced by the use of pragmatic and syntactic rules appropriate to the communication context (Kent, Mielo & Bloedal, 1994). Studies of communication efficacy have in the past focussed on isolated components of language content, form and use. The intelligibility of utterances was studied through explorations of the phonological system. These studies indicated that a broader approach was required and that intelligibility was influenced by content, syntactic form, pragmatic function and context. It was recognised that intelligibility is influenced by the semantic characteristics of words with nouns produced with greater accuracy than verbs (Kent 1992b). It is also influenced by the length and fluency of the utterance frame and word location within that frame influences (Weston & Shriberg, 1992). Furthermore, speech intelligibility is influenced by the function of the utterance, the level of communication intent and by listener uncertainty or expressed misunderstandings of message content (Kamhi, 1992a; Weiner & Ostrowski, 1979). Restrictions on any component system will influence the functioning of the other systems and of the language system as a whole. Influences on the phonological system are illustrated in figure 1.1 which summarises some of the suggested interactions noted in reviews of research on relationships within spoken language (Crystal, 1987; Hoffman, 1992; Kamhi, 1992a, b).

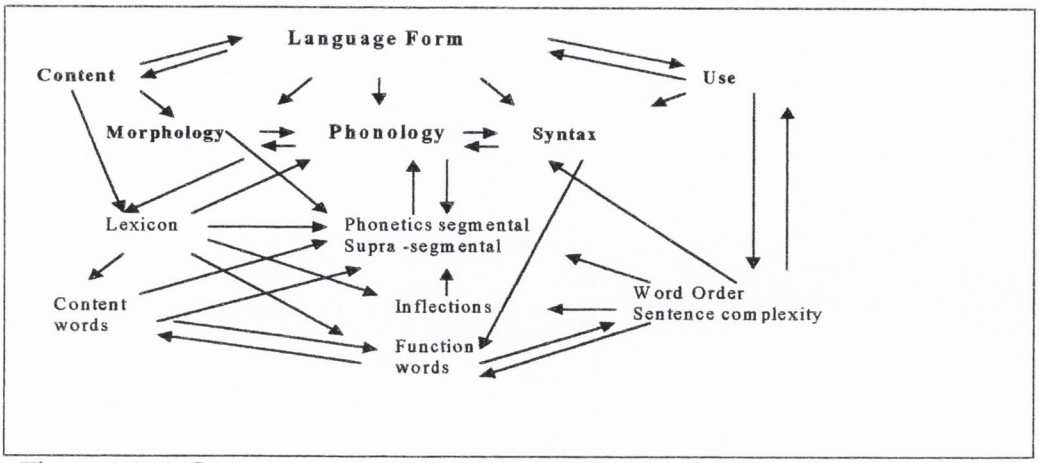


Figure 1.1. Influences on speech as a carrier of language

Variation in form between languages is characterised by differences in both the speech sound inventory and in the phonological, morphological and syntactic rules that are applied to the use of these sounds for communication. The study of variation in language form is characterised by a diversity of approaches across different disciplines. These disciplines identify and approach questions on the nature, structure, and functioning of language from a variety of perspectives. The study of language in speech and language pathology and therapy has been influenced and stimulated by developments in linguistic and psychological knowledge and research methods while at the same time retaining a strong medical influence in approaches to classification and causation.

1.3. Approaches to the study of spoken language

Approaches to the study of speech and speech impairment during the twentieth century are outlined in this section.

Subjective form

At the beginning of the century, the focus of the scientific study of language in linguistics was on the identification of patterns of sound correspondence across languages both synchronically and diachronically. The evolutionary theories of the

age provided the paradigms and methodology for linguists who worked to identify the nature of the parent language and the common characteristics of the offspring. While those studying language scientifically pointed out that no language was intrinsically better than any other the evolutionary beliefs of the age reinforced beliefs in a standard language form with variations from this norm frequently considered as sub standard, deviant or adulterated. These beliefs influenced many approaches to language variation over the century. Social judgements of language form are still evident in social policies and in theoretical approaches to variation both within and across languages.

Approaches to the study of language in the sciences during the twentieth century were influenced by the general paradigms of each era. These are summarised in table 1.1.

Table 1.1 General influences on approaches to the study of speech

Focus	Goals	Assumptions
Objective Form	Identify formal properties of systems	Universal rules
Abstract form	Identify universal form	Deep structures underlie observable signs
Reality rooted abstract form	Identify real system components	Reality base (anatomical, neurological) necessary to sustain abstraction
Interactive systems	Identify processes that mediate between components	Relationships between components more significant than individual components
Connectionist	Identify networks that facilitate performance	Mastery indicated by performance in forging links or networking

For the purpose of this study, the focus has been narrowed to linguistics and psychological approaches and frameworks, which have directly influenced clinical research and practice on speech as a component of language form.

Objective form

The central focus of linguistic inquiry moved from historical linguistics to synchronic linguistics in the first decades of century. The study of observable speech sound systems developed with the rise of structuralism and the strong influence of behaviourism. The concept of the phoneme as the basic element of speech developed in the American school under the influence of Bloomfield while in Europe the feature was considered as the basic element in the work of Trubetzkoy and Jakobson at the Prague School. The sound systems of languages were viewed as learned behaviours and variation in these systems were explained by individual use of the learning opportunities provided by the linguistic environment. The detailed analysis study of speech sounds and sound systems within language gave rise to speculation that diversity existed at surface level only and that all languages shared a universal deep structure. The influence of cognitive psychology and the reduction of the explanatory power of behaviourism facilitated the exploration of language as a cognitive system.

Abstract form

The search for the universal structure became the goal of generative linguists following the teachings of Chomsky from mid century onwards. Generative linguistics focussed on abstractions at mind level and sought to explain a universal grammar that was competence based and uncoupled from the imperfect performance of speakers. The Universal Grammar was held to contain the innate rules of grammar and phonology which transformed the deep structures of sentences into their surface structures. Language learners were guided by an inbuilt language acquisition device in their selection of language specific structures from the grammar.

Models based on generative phonology as defined by Chomsky and Halle's *Sound Patterns of English* (1968) were devised to explore and explain developmental variation and speech impairment. Smith (1973) outlined possible explanations for

developmental variation by proposing that children use realisation rules to determine on output from their underlying adult like representations. This approach allocated more rules to child than adult systems. This result was unacceptable to others such as Ingram (1976), who accounted for variation by the inclusion of an additional level of organisational rules to mediate between perception and production. Generative rule based approaches dominated explorations of phonological development and impairment until the eighties and the efforts of generative linguistics to account for all structures led to a proliferation of rules. Modifications to the theory reduced the parameters to be set by the innate grammar (Chomsky & Lasnik, 1993). The role of environmental triggers in parameter setting was incorporated in theoretical approaches. Linguists worked to identify the principles and parameters underlying the structures of all languages and the environmental triggers required to set the parameters (Bickerton, 1996; Lightfoot 1991).

In the nineties approaches to the Universal Grammar began to focus on the lexicon. The Minimalist Program (Chomsky, 1995) proposed that the parameters for language along with functional phrases and inflections are held in lexical entries and that acquisition involved harnessing lexical traits for representational functions. The Minimalist Programme refocused attention on the lexicon as a repository of linguistic knowledge. The concept of a word has been enlarged to incorporate syntactic parameters in semantic form.

The variability of language in use did not present as an issue to those attempting to identify the abstract language universals. Speech and language therapists, of necessity, focus on the variable speech of real speakers as they seek to communicate with others in their environment. Generative approaches provided the profession with rules, which facilitated description, but not explanation 'Phonological rules elegantly explain what children do, they do not explain why or how they do it' (Dodd, 1995:43). Descriptive tools and concepts from generative linguistics have informed theories and therapy for children with communication

impairment but therapists have augmented these with additional frameworks from functional linguistics and psychology.

Reality rooted abstract form

While generative linguists were focussed on abstract form, others sought to identify explanation for language universals by exploring the influences of anatomy and physiology on speech. In the sixties, Stampe (1963 cited in Ingram 1989) proposed a theory to link the rules underlying language universals with structural constraints on human perception and production. The theory of Natural Phonology, which developed in the next decade, had a major influence on speech and language therapy. Donegan and Stampe (1979 cited in Ingram, 1989) viewed processes as mental representations, which allowed phonetic intentions to be related to phonetic capabilities. Phonological processes were based in human perception and production capabilities, which facilitated goal related production of phonemes in the speaker and goal related interpretation in the listener. Processes were viewed as innate and universal and could account for changes in both developing child phonologies and in adult speech patterns. Stampe (1972 cited in McMahon, 1996) suggested that conflicts between individual phonologies and language specific systems were resolved through suppression, limitation or ordered application of the conflicting processes.

The theory of Natural Phonology did not impact greatly on the predominantly formal linguistic frameworks of the time but facilitated diagnosis and therapy for those with speech impairment following the work of Ingram (1989). Phonological process analysis facilitated the identification of patterns in restricted phonological systems. Remediation programmes based on natural phonology were found to be more effective with many client groups than those based on phonetic approaches derived from structuralism or the feature and rule based approach of generative grammar. These frameworks allowed for the systematic analysis and interpretation of the 'how' of phonological impairment but not the 'why'.

Towards the end of the century developments in articulatory and acoustic measurements and connectionist modelling systems led to a variety of new approaches to phonological theory which may enable causal mechanisms to be explored. These include Optimality Theory, which developed from a base in generative theories and expanded rapidly to influence approaches to many aspects of language (McCarthy & Prince 1995; Prince & Smolensky, 1993).

Optimality Theory proposes an output based grammar where constraints replace rules and processes. These constraints are universal, violable and ranked and their goal is to match output with input in the most harmonic form possible. Constraints are used to explain both universal generalizations and language specific forms. The universal grammar provides the range of possible outputs and a set of constraints to ensure that selected outputs are optimal for spoken language. The language specific grammar ranks the universal constraints to ensure optimal outputs for that language. Constraints can be viewed as linguistic pressure on the phonological system to maintain or modify outputs. Faithfulness constraints require input and output forms to be identical. If segments are omitted, added, or undergo featural changes FAITH is violated. Faithfulness constraints include:

- MAX – a constraint against deletion of segments
- DEP a constraint against insertion
- IDENT feature – a constraint against changes in manner or place of segment production

Markedness constraints enforce well-formedness and require outputs to be unmarked or simplified in structure and / or segments for example:

- *CODA - a constraint against final consonants
- *COMPLEX ONSET- a constraint against consonant clusters syllable initially
- *FRICATIVES – a constraint against fricatives

- *LIQUIDS – a constraint against liquids

Optimality employs two functions to generate and evaluate output. The GENerator provides each input with a range of output candidates. The EVALuator selects the candidate that best satisfies a set of language specific ranked constraints.

Optimality theory provides analytical frameworks, which allow explorations of both the formal properties of the grammar, and of developmental and cross-linguistic variation. Perceptual distinctions based on factors such as sonority, and articulatory distinctions based on phonetic complexity have been incorporated into phonological explanations. Developments by Boersma, (1998; 1999; 2000) Hayes (1999b) and others have integrated these phonetic and perceptual factors into the grammar. The incorporation of the dynamic aspects of speech production into a formal theory of phonology allows both developing and impaired motor speech systems to be explored holistically. Acquisition studies have used the framework to model the development of syllable structure and feature change (Gnanadesikan, 1995; Levelt & Van de Vijver, 1998).

Interactive systems

During the period when the influence of generative linguistics dominated the study of phonology and syntax, the explorations of other domains and components of language continued with studies in developmental psychology, functional linguistics, psycholinguistics, sociolinguistics and comparative linguistics gathering knowledge on language content and use. Developmental psychologists such as Brown, Bruner and Piaget proposed theories to account for the development of semantics and the lexicon. Studies of these language domains revealed regularities within domains and patterns of developmental and context related variation.

Functional linguistics

Functional linguistics as a discipline bases language in theories of social interaction and explores the linguistic system in reference to the communicative behaviour of speakers and listeners. Functional theories address areas of language form through the analysis of speech acts and speech events (Halliday, 1994). They focus primarily on the identification of pragmatic influences on the semantic and syntactic frames or schemata, which support verbal communication. This results in units of speech being examined at clause or sentence levels (Halliday, 1994). The integration of language content, form and use allows the cognitive and social motivations behind communication to be explored but the units of study have not been found to be sufficiently detailed for study of speech impairment. Factors identified by functional linguists have contributed to clinical interpretations of speech impairment and influenced approaches to therapy, but functional approaches alone have not been found to facilitate systematic change in restricted phonological systems (Fey, 1992; Fey, Cleave, Ravida, Long, Dejmal & Easton, 1994).

Sociolinguistics and language change

Sociolinguistic studies and studies of language change explore variation and change in language content, form and use at both macro and micro levels. Language develops and changes form as speakers and listeners work to communicate effectively in social interactions. Phonological changes are evident on the individual as speakers seek to conform to the social norms of the groups with whom they identify. These changes may influence the consonant and vowel inventory, and may in addition determine the rules that are applied, the processes suppressed or the constraint ranking to achieve a satisfactory output.

Variability in form distinguishes languages from each other at community level. Studies of language change explore patterns of variation and change both within a language over time and across languages. Studies of phonological change in languages have identified markers, patterns and processes which allow

phonological change to be integrated with language content and use. These are more evident diachronically in situations of language contact where speakers of different languages need to communicate verbally in a limited number of contexts. In these situations, the form of the ambient languages may be modified and new codes such as pidgins and creoles, which allow language change to be studied, may emerge. A pidgin arises as a functional verbal code when communication between speakers of different languages is necessary to serve a limited range of functions. It has been noted mainly in the contexts of trade and slave / migrant labour. Speakers borrow speech sounds, words, and structural rules from those of the listener and combine these with their native language forms. These borrowings are restructured and reduced in form. Phonological contrasts are reduced and use of morphological and syntax structures simplified.

Many theories have been proposed to explain how pidgins develop, stabilize, and expand. Bresnan (1998) explored the simplification processes in pidgin genesis and proposed that the creators of a pidgin use their native language base to simplify the language by promoting low-ranked markedness constraints above the corresponding faithfulness constraints. The native language is simplified by the elimination of marked features. Markedness constraints are promoted above faithfulness, in a reverse of the pattern seen in language acquisition, until a functional base for communication is determined. The distance to be travelled depends on the rankings shared by the ambient languages. Pidgins developed by speakers of languages, which differ in many parameters, would be expected to show maximally unmarked forms common to all languages. This pattern is frequently observed in communication directed by mature language speakers at non-proficient language speakers. The impact of highly unmarked input on spoken language learners has not been studied directly but studies of deaf children developing sign language in similar contexts would indicate that this may support the development of creole structures (Pinker, 1994).

Pidgins may be used briefly and discarded during periods of rapid migration. In other situations, they may survive and stabilize to become a relatively fixed or

creole code. Linguists have identified regularities in patterns of change in pidgins and creole languages as they move towards the standard language. These are outlined in table 1.2.

Table 1.2 Linguistic tendencies in Pidgins and Creoles

Linguistic element	Pidgins	Creoles
Syllable structure	CV syllables	Increases
Phonetic realisation	Variability tolerated	Stabilises
Phoneme inventory	Reduced of marked structures	Increases and stabilizes across lexicon
Phoneme use	Flexible contrasts	Stabilizes
Lexicon	Limited	Expands and adapts to phonological system
Semantic extension	Reduplication	Fixed number of lexical items
Labels	Generic	Specific
Adjectives	Infrequent use	Used as verbs
Word order	Varies	Development of fixed word order
Article	Not used	Specifier to mark status
Pronouns	No case marking	Case marked obliquely
Prepositions	Omission	Limited
Gender	Omission	Limited
Plurals	Omission /number	One form develops
Agreement case	Omission	No NP-movement
Verb morphology	Omission	Use of some markers
Time markers	Anterior marker	Preverbal markers
Wh-words	Intonation	Who or what plus location, time, cause, person, etc.
Predominant clause pattern	Omission	Subject – verb- object

Similarities between these features of pidgins and creoles and developmental markers in child language resulted in speculation that the language system followed a similar pathway in both. The linguistic tendencies reported in pidgins and creoles are evident in individuals with impairments of the verbal language systems, and some have been used as diagnostic markers of specific impairments. Bickerton (1984; 1996) suggested that pidgin and creole codes shared semantic structures and pragmatic functions with the early utterances of children and differentiated this from formal language by the term protolanguage. Creole languages show many features typical of early syntactic development in children

and he suggested that these reflected the innate grammar. He incorporated this hypothesis into the Bioprogramme theory, which had a unified approach to creoles, language acquisition and the origin of language. The Bioprogramme did not gain acceptance as a linguistic theory, with some disagreeing on the content of the bioprogramme and others holding that any similarity can be attributed to the nature of restricted human communication systems. Aitchison (1989) argued that similarities were due to the snowball effect of one solution impinging on all aspects of the language system. The arguments put forward by both Bickerton and Aitchison encouraged an integrated approach to content, form and use in situations of language change. The identification of patterns of change across the components of language form was neglected in many approaches to speech impairment in the past, but evidence from studies of language change supports the need for an integrated approach and an awareness of continuous linear and non linear change in spoken language form.

Continuity and discontinuity

Approaches to continuity in language form vary greatly across disciplines. Studies of language change recognize many continua both in speakers and in languages. Variations in comprehension and performance along many oral and written language continua are frequently used in studies of second language acquisition and bilingualism. Creole studies have attempted to unify patterns of variation across a code by using the concepts of continua and lects. Speakers are seen to control a span of lects or individual usage patterns on a continuum ranging from pidgin to the standard language. The selected range will vary according to social activities and group membership (de Camp 1977, cited in Wardhaugh, 1996). Dialect studies have indicated similar variation on continua associated with social factors. Factors associated with variation include personal factors such as gender, age and education and social factors such as status and solidarity. Studies by the Milroys (1987) indicated that membership of specific social networks could inhibit or facilitate changes in speech. Participation in multiple loose networks

was found to promote change in speech patterns while membership of networks, which were small in number and limited in sphere, resisted change.

The concept of continua in speech combined with the concept of social networks may provide some explanation for the reduced movement toward the mature language system encountered in those with speech impairment and learning difficulties. Therapy may trigger movement towards the community system, but if all communications functions can be served by a home code in dense social network growth may be arrested.

Interactive systems

Psycholinguistics and neurolinguistics focus on developing knowledge of the relationship between the grammar and the psychological and neurological processes used in speech perception and production.

Psycholinguistic modelling

Psycholinguistic approaches use theoretical models to identify the key components and processes involved underlying speech perception, processing, and production and to relate these to communication impairments. Models vary in their theoretical orientation and in the detail in which they explore the input storage and output of the speech system.

The model in figure 1.2 based on that of Stackhouse & Wells (1997) illustrates the type of models currently in use to identify and explore components of the speech system.

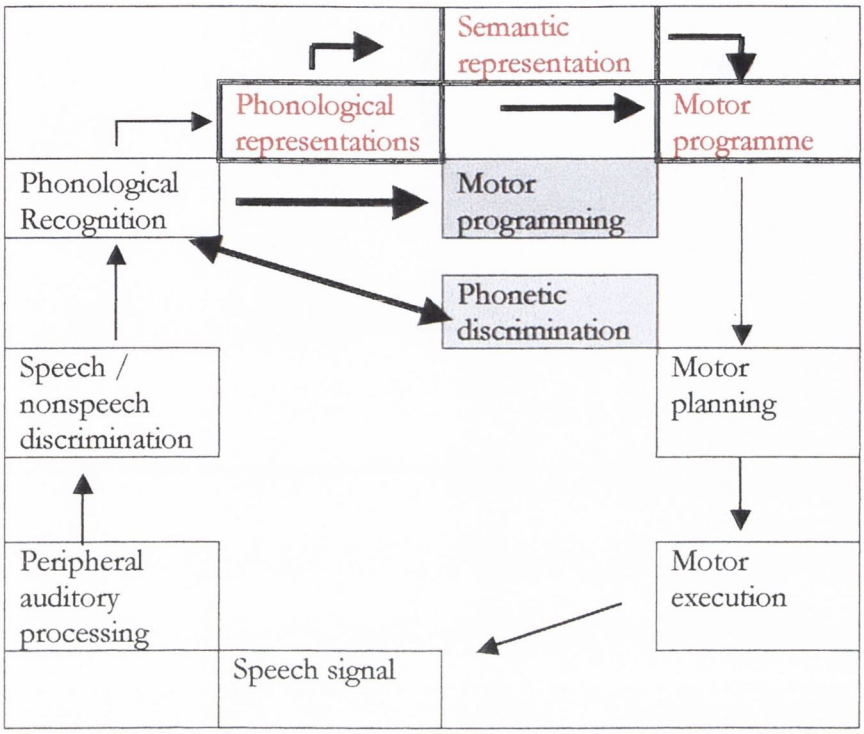


Figure 1.2. Speech processing model based on Stackhouse & Wells (1997)

Stackhouse and Wells (1997) proposed that the lexical representations, which support the speech system, are contained in the semantic, phonological and motor information systems (in red). The input and output processes to and from lexical representation are indicated by the boxes and connections. Bold arrows and shaded boxes represent off line activities. The model has been used to identify deficits associated with spoken and written language impairments; in addition; it has fostered the development of deficit focussed therapy and remediation programmes.

Psycholinguistic models vary in their theoretical approaches to language and learning and consequently stress different components and processes. They provide frameworks for detailed and focussed investigations of the components of speech processing and have been used to investigate both developmental and

impaired processing (Dodd, 1995; Howell & Dean 1994; Stackhouse & Wells, 1997). The information obtained from modelling has been used to formulate and test hypotheses on the components of speech and language in clinical and educational settings.

Connectionist

Connectionist computer based models are increasingly being used to test and evaluate theories of speech processing. Connectionist approaches to modelling use computer architecture and mathematical formulae to design and activate learning networks. Connectionist networks are self-organising systems designed to mimic neural systems. They can extract general principles from finite and degraded input. During learning, they show linear and non linear change and have potential for overgeneralization and self correction (MacWhinney, 1987; MacWhinney, Leinbach, Taraban & McDonald 1989; Rumelhart & McClelland, 1986 cited in McWhinney, 1998; Tesar & Smolensky, 1998). The networks reflect the theoretical assumptions of their designers about language and speech systems in the nodes selected, the connections established, and the preset connection strengths. Connectionist models have been used to explore semantic, syntactic and phonological aspects of language and have provided insights on the nature of linguistic representation, the processing of linguistic information and the learning strategies used in acquisition.

Studies using connectionist modelling and Optimality Theory frameworks have explored the role of learning in phonological development. Findings from these studies have questioned assumptions on the nature and innateness of language. Studies have indicated that self organisation emerges early in development and some have suggested that primed sensory-motor systems may be all that is innate (Boersma, 1998; Boersma & Hayes, 2001). These approaches suggest that languages use a limited number of phonological features and organise articulatory and perceptual space values to match the ambient or native language system. Categorical learning maps the perceptual space of a phonological system. Motor

learning maps the articulatory space and defines the gestures that function phonemically in a language.

Boersma (1999) has shown how a learner masters the optional realisations and variations shown by the ambient language using a stochastic learning algorithm. The learning process modelled showed patterns of overgeneralizations and self correction mirroring the rote to rule, rule to rote pattern seen in child development. The role of the lexicon in constraint setting has been explored and frequency identified as a factor in the development of syllable and word structure (Levelt & Van de Vijver, 1998).

Connectionist approaches to language learning have influenced many disciplines and have encouraged multidisciplinary approaches to the study of language. Such approaches may facilitate the development of new frameworks to model and explain interactions between the sub domains and components of language in speakers using language to communicate across a variety of contexts. Theories and frameworks, which allow explorations of all components of language to be modelled and computed such as Optimality Theory, may provide the catalyst needed to develop unified theories of language and speech variation in exceptional circumstances.

The key theories and frameworks, which have informed and influenced approaches to speech and speech impairment in speech and language therapy are summarised in table 1.3. The table follows an approximate timeline through the century but with overlapping acknowledged by the broken lines.

Table 1.3. Influences on, and approaches to, speech and speech impairment

Phase / Focus	Linguistic	Psychology	Medicine & Neurology	Speech and language therapy
Objective Form	Neo grammarians Naturalistic	Objective psychology Behaviourism Measurement of attributes including intelligence	Chromosomes and heredity Measurements of physical attributes Neural localisation of functions	Diagnosis and therapy based on observable phonetically motivated units S-R learning
Abstract form	Generative phonology	Cognitive psychology Memory Artificial intelligence Social learning Humanism	Neural studies of functioning Neurotransmitters	Segment as surface representation of deep form Phoneme, Rule, Feature focus in therapy S-R learning
Reality rooted abstract form	Natural phonology	Learning - Perceptual, cognitive, social Developmental psychology	DNA research Physical and behavioural classification linked to genetic studies	Phonological rules/processes as part of system Constructivist /Functional approaches to diagnosis and therapy
Interactive systems	Non-linear phonologies e.g. Auto segmental, Metrical, Lexical	Cognitive psychology Artificial intelligence Humanistic Sociolinguistic	Environmental influences on development and functioning of physical systems	Integration of prosodic, syllable, and featural tiers Models to identify systems and deficits / strengths for therapy
Connectionist	Non-linear phonologies Optimality Theory Functional phonology	Psycholinguistic models and Connectionist networks of systems underlying speech perception, processing and production	Structure and functioning –Imaging studies to identify systems and processes	Network models Key units – phonemes, syllables, words Learning- rote to rule, rule to rote processes, constraints.

No one theory has yet emerged to unify and explain the systems and strategies observed in speakers using the verbal code to communicate. Current approaches to language form in speech and language therapy are eclectic in nature and reflect influences from many disciplines.

1.4 Speech and language development

The movement of infants from early cries to verbal communication has been studied by many disciplines for many purposes. The developmental process has been explored to explain language origin', to validate theories on the nature of language and to gain information on learning and socialization processes. Findings from diary studies, cross-sectional studies and experimental research have resulted in a broad knowledge base of the milestones of language development, but the interpretation of these findings varies according to theoretical approaches to the nature of language and verbal communication. Reviews of studies of prelinguistic and early language development indicate that while children follow the same general pathway towards intelligible speech, they show variation in learning strategies and in age related developmental achievements (Bates, Thal, Finlay, & Clancy, 1998; Dodd, 1995; Ingram, 1989). This section outlines the milestones associated with the development of language knowledge and verbal skills with a focus on those relevant to speech during the first four years of life.

It is generally accepted that the neonate enters the first stage of development with an innate potential for verbal communication and a biological system which may be pre-set or attuned to speech. Theories vary in their definition of the initial state on nativist–behaviourist and mentalist-functionalist continua as illustrated in Figure 1.3. Most current theories cluster around a central point which allows for innate potential changing or being modified by the environment with the black box of earlier theories being replaced by 'a set of predispositions to acquire the sound system of his or her native language' (Schwartz 1992:108).

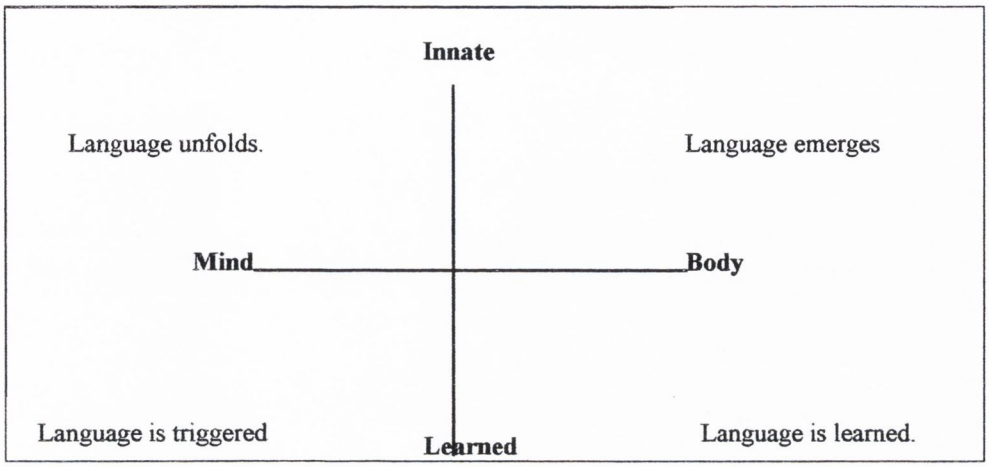


Figure 1.3. Perspectives on language development

Theories differ in their views on the nature of developmental change and of the motivational and environmental forces that initiate and maintain change. Views on these aspects have modified in many theories over the past decade and most now allow for a transactional relationship between the developing infant and the responsive environment. Transactional approaches can reflect changes in the infant and in the linguistic environment, which may account for the various routes followed to arrive at the same goal of functional verbal communication.

Theories of neural development show a similar shift away from linear relationship and towards transactional models in the last decade. Recent studies to identify associations between the development of language and changes in neural organisation and functioning indicate that there is little evidence to support the notion of modular brain systems activating at set points in maturation. Most now accept that the relationship between neural development and environmental experience is transactional. 'Brain maturation affects experience, but experience returns the favour, altering the very structure of the brain' (Bates et al., 1998: 59).

During the early years, infants develop the articulatory skills that underlie speech and the perceptual, cognitive, referential and inferential knowledge that underlie verbal language. Developments do not occur in isolation, but are motivated and nourished by interactions with the physical and social environment. The

developmental achievements of infants as they progress towards the use of speech as a channel for language can be divided into three broad stages.

a. Get Ready: Approximate age range: 0-12 months

b. Steady: Approximate age range: 12-18 Months

c. Go: Approximate age range: 18-48 Months

These stages are not discrete and variation in developmental rate and pathways are reported. These variations arise both from environmental influences and from variations in the temperament and learning style of the infant.

a. Get Ready

During the first year infants begin the path towards independent existence with rapid growth and developmental changes occurring in all aspects of physical structures and functioning. Changes in one system will influence developments in others, both within the infant and in the environment, and consequently the pathways outlined here are broad and ages of achievement of behavioural milestones approximate.

Development of neuromuscular control

The infant begins to develop the motor control necessary for speech with the reflex coordination of respiration and vocalization at birth. During the first year rapid musculo-skeletal and neurological changes accompanied by motor experience gained in feeding, vocalisation and imitation facilitate the modification of reflex patterns to allow the development of differential movements of the lips, tongue, jaw, velum and vocal cords.

Increasing motor control is reflected in changes in feeding patterns. Neonates are dependent on gross movements of the mandible in early suckling. These holistic movements are differentiated within the first three months with the development of sucking and swallowing reflexes facilitating independent movements of lips and tongue. Further disassociation of lip and tongue movements is evident as lip closure develops and infants begin to take semi-solids by four to five months. Lip closure and tongue tip movements develop as the infant learns to bite and retain food intra-orally. The nutritional needs and demands of the growing infant ensure frequency of feeding with resultant practice of oral movements and by the end of the first year basic biting, chewing, and swallowing reflexes are established for eating and drinking. The increasing voluntary control of the oral muscles is reflected in the wide range of refusal strategies at the disposal of the year old child at mealtimes.

The relationship between the oromotor skills used in feeding and those used for speech motor control has been debated with some holding that feeding provides a coordinative infrastructure for speech while others argue that the movements required for speech are physiologically different (Kent, 1992 a; Kent, Mitchell,& Sancier, 1991; Moore & Ruark, 1996). Associations between oromotor movements in early feeding and vocalization patterns have been identified. These may be attributed to the musculo-skeletal and neurophysiological changes seen in the vocal tract during this period or to the facilitative effects of feeding routines on vocalizations (Strand, 1992). Movement patterns in the second half of the first year become increasingly goal directed with resultant divergence in oromotor patterns.

Affective reflex vocalizations during the early months facilitate the development of oral motor control. The rapid transition from the undifferentiated reflex cries of the neonate to a range of affective vocalizations by three months provides evidence of developing motor control. The vocalizations of infants over the next three months show an increasing ability to achieve a range of pre consonantal

constrictions and by six months a wide range of consonantal approximations are present in sound making.

Between six and nine months, the range of both consonant and vowel sounds increases and vocalisations begin to reflect the prosodic patterns of ambient language. Vocalisations during this period are used for interactional purposes as outlined below but infants also appear to be actively exploring the 'possibilities for sound production of the vocal tract' (Dodd, 1992:25). The development of imitation, cognitive and interactional skills foster additional motor development during this period, and by twelve months, the infant has developed basic oral motor skills and a motor planner that facilitates automatic control of a repertoire of sounds and sound sequences.

Development of perceptual and conceptual skills

Auditory

Infants are attuned to their mother's voice at birth and prefer to listen to her above other females (DeCasper & Fifer, 1980). They also show a preference for listening to the native rather than non native language (Moon, Cooper & Fifer 1993). These preferences indicate a degree of perceptual readiness, which rapidly develops into an ability to discriminate and recall both speaker and language specific characteristics.

Recognition and recall

The formation of speech sound percepts and early phoneme concepts accelerates rapidly between four and six months. Awareness of syllable structures, memory of syllable sequences and discrimination of non native language forms was found in infants at four months (Bijeljac, Bertoncini & Mehler, 1993; Jusczyk, Jusczyk, Kennedy, Schonberg, & Koenig, 1995). Further studies found that prosodic and intonational cues aided speech discrimination and recall (Mandel, Jusczyk, & Kemler-Nelson, 1994). Syllable stress facilitated learning of syllable sequences and syllable structure (Aslin, Jusczyk, Tager-Flusberg Calkins, & Pisoni 1997; Jusczyk

& Aslin, 1995). Recognition of the constancy in syllable structure patterns may highlight constancy of the phoneme as unit of speech and inconsistency in phonetic realizations. This recognition facilitates transition to the speech focussed learning stage, which begins at six months.

Discrimination and classification

Studies by Kuhl (1991) indicate that infants identify central aspects of speech sounds and use these as perceptual magnets to discriminate between the phonemes of the ambient language. The perceptual frames for speech sound discrimination begin to contract between six and nine months and knowledge of native language phonemic contrasts becomes evident in perception. There is an increased focus on native language phonemes and the ability to detect contrasts in non-native languages decreases (Kent 1992 b; Werker & Tees, 1984 cited in Hayes, 1999b). The development of phonemic categories begins with the infant showing recognition of similarities and differences between sound classes based on abstractions of key elements. The early recognition of goal directed variation in phonetic realizations facilitates the development of receptive language by alerting the child to the relevant sound contrasts and word shapes in the speech of others. It also contributes to the formation of distributional proto-categories as building blocks for later phonological knowledge (Hayes, 1999 b; Kuhl, 1991). Knowledge of the phoneme inventory, contrasts and phonological rules are evident in perception by the first birthday.

Visual

Neonates focus on, and track, visual stimuli that resemble human faces from birth. Tracking responses can be elicited to highly stylised faces such as ☺ providing sufficient foreground / background contrast is present. Attention to the eyes and mouth of caregivers facilitates the development of two key speech and language learning processes - joint attention and imitation.

Development of joint attention

Caregivers and infants begin face to face interactions at birth and develop these into routines and games involving mutual regard, imitation and affective information exchange. These early interactions develop awareness of eye gaze patterns and by four to five months, the infant follows the caregiver's eye gaze when this diverts from mutual regard. This development allows a shared focus on objects and events beyond the dyad. The ability to use eye gaze to establish joint reference facilitates language learning by ensuring that the infant tunes to objects and events that match the verbal input of the caregiver. Infants, at seven to eight months, indicate comprehension of the communicative use of eye gaze by using it to draw the attention of others to objects and events in the environment.

Development of imitation

Imitation, the ability to transform a visual or auditory model into a motor output, assists the transition from reactive primitive movements to proactive sequential motor skills. Imitation prepares the infant for participation in the society by reinforcing and strengthening observed human behavioural patterns. Imitation was viewed in the past as an early form of learning through which innate reflexes were moulded by social forces into voluntary movements. Information from studies of imitation in neuropsychology and neurophysiology has indicated that imitation as a learning process involves the active reconstruction of observed actions by the infant.

Imaging studies identified specialized neurons, which fire when an action is either performed or observed (Rizzolatti, Fadiga, Gallese, & Fogassi, 1995). The identification of mirror neurons provided a framework to link perceived and performed motor sequences in a common cross modal framework and imitation is now viewed as an active learning process as outlined in figure 1.4.

Imitation serves as a learning tool as infants actively strive to reproduce an observed target pattern by comparing proprioceptive feedback to the specified

target behaviour. This begins shortly after birth and can be observed in the mirroring of facial expression and mouthing movements in early parent-infant interactions. Imitation of speech provides a mechanism to foster crossmodal development of the auditory, visual, proprioceptive, kinaesthetic and motor skills which may form the basis for the representational processing required for speech production.

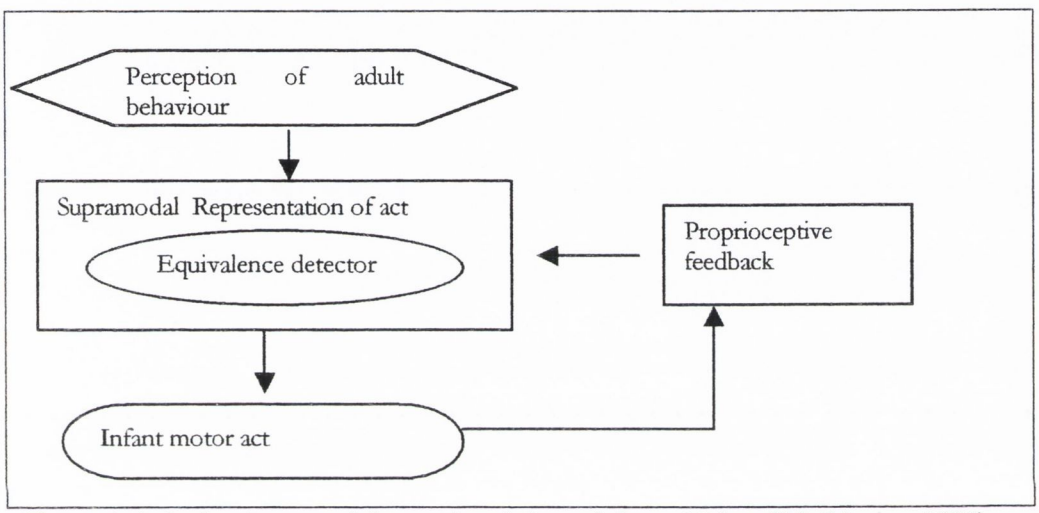


Figure 1.4. Active intermodal mapping (adapted from Meltzoff & Moore, 1999)

The cross modal nature of early imitation is supported by findings of studies by Kuhl and Meltzoff (1988). These studies found that infants at two to three months could discriminate rounding and spreading of lip movements associated with the /ʊ/ and / i / vowel sounds and attempted to imitate the appropriate sound when both sound and image were presented together. There was no attempt to imitate when the stimuli were presented separately. These findings would indicate early development of separate visual and verbal representational forms similar to the imagens and logogens used for associative processing (Paivio, 1986).

Imitation and interaction

Imitation facilitates preverbal interactions and fosters the development of turn taking skills necessary for interpersonal communication. Infants begin to respond

to the movements and sounds of others shortly after birth by synchronous movements and mirroring of expressions. Caregivers in interactions with young infants actively encourage imitation of facial expressions and oral movements. They are rewarded by the first smile, and imitation routines increase, with adults encouraging a range of lip and tongue movements that will be later used for speech. Caregivers and adult members of society respond intuitively to infant eye contact and smiling by providing opportunities to imitate movements, gestures and sounds. From four months onwards, infants show a rapid increase in the range of vocal imitations and are actively encouraged in this by caregivers. Caregivers perceive infants sounds through their own phonological systems and respond to them using their native language phonemes. Infant babble patterns drift into language specific patterns around nine months. Caregivers recognize this shift and begin to provide word forms for the child to imitate in routines, social interactions and stylised speech and action games. These patterns become entrenched in memory and deferred imitation at nine months indicates that the infant has a repertoire of multi modal motor patterns available for use by physical, cognitive or language systems.

Memory

Studies and theories of memory vary in their definitions of both processes and outcome. The process of remembering is generally divided into two stages. The initial stage referred to as short-term or working memory covers the initial processing of stimuli, which may be then discarded or passed into the general system for long term storage. Items based in implicit memory are generally not accessible to conscious processing but may surface as recognition when experiences are repeated. Procedural memory refers to learned motor habits, which functions mostly at a subconscious level but remains subject to conscious recall. Accessible memory storage system include declarative memory where facts are cognitively stored, episodic memory which encodes holistic memories of events and spatial memory which retains information on location and locative action. These memory types have been tentatively associated with patterns of neural firing identified by imaging studies. These would suggest that orbitofrontal

cortex and amygdala are involved in affective learning and in the development of crossmodal representations. The temporal cortex has been associated with representational memory while the hippocampus stores spatial and episodic memory (Roll, 2000).

Short term memory involves activation of frontal and temporal cortical areas. Specific tasks may trigger variation in the duration of neuronal firing and activate distal cortical areas. Current findings would indicate the involvement of possible links between the temporal and prefronatal cortex in short term recall but definitive studies have yet to be completed. There is little agreement on the path from short term to long term memory. Two main theories have been used to explore associations between memory and language processing in the past decade. Separate serial processing mechanisms were proposed for auditory and visual processing and short term recall by Gathercole & Baddeley (1989). Short term storage of verbal information was linked to a phonological loop, which served to refresh and hold information on line while awaiting for the central off line processors to activate. The central processors decoded and stored the semantic and syntactic information in long term memory. This model was used to investigate the long established association between difficulties in short term recall and speech and language impairment. Findings from studies indicated correlations between deficits in short term memory patterns and specific language impairment, vocabulary deficits, phonological impairments and reading difficulties. Many explanations for this association were proposed but causal factors have yet to be identified. Constructivist psychologists proposed alternative models of memory that allowed on line access to the knowledge stored in long term memory. These models reflect findings from imaging studies and allow for the integration of short term processing with long term memory and lexical knowledge. Explanations under this model hold that difficulties in short term recall are associated with restrictions on categorisation of information and / or disruptions of the processes linking new information with long term storage.

The ability to process, retain and recall sensory information is present in early foetal life where studies using habituation have established recall of sound, light

and taste sensations. Memory capacity increases rapidly in the first months of life and studies indicate that by six to seven months functional long term and short term memory strategies are used by infants to recognize and recall objects and events. They look for familiar objects in familiar environments and search for hidden objects. They show anticipation of routine events in response to associated olfactory, visual and auditory cues. Studies of short term memory indicate that eight month old infants recognize sequences of motor, visual and auditory patterns after brief exposures. Studies of deferred imitation indicated that infants at this age retained and recalled novel imitations in memory for periods of a month (Meltzoff, 1988 cited in Meltzoff & Moore, 1999).

By eight to nine months infants can retain sound sequences in memory and associate these with people, objects and actions as they begin to develop understanding of verbal language.

Environmental knowledge and concept formation

Infants accumulate knowledge of objects, actions and events in the environment during the first year. Habituation studies show that infants begin to recognise familiar shapes, smells, sights and sounds from birth, if not before, but understanding of how they process, code, retain and recall this information is limited. Developmental markers of knowledge acquisition are few and there is disagreement on what is signified by milestones in this aspect of development.

Infants need to learn about objects and events in the world in order to form mental representations that will enable them to hold these in memory and encode then in verbal language. They need to learn that objects exist independently in the environment. Infants show recognition of their mother's voice at birth indicating that a degree of permanence is present from the early stages. They track her voice with eye, head, or trunk movements as these motor responses become available to them, which could also be indicative of concept formation and early inferential thinking. Infants demonstrate increasing awareness of the permanence of objects and people in the environment during the first six months as they begin to

disassociate objects and events from the environmental gestalt. This process continues with increasing abstraction over time and place until the infant shows full mastery of object permanence at sixteen to eighteen months.

Studies of concept development in the preverbal infant indicate early recognition of similarities and differences in all sensory modes. Categorisation of objects and events by pattern, shape, use and other attributes develops rapidly during the first nine months. Categorisation skills are evident in the environmental explorations of the infant as motor coordination develops.

Interaction and communication patterns

The foundations for speech as a channel for interpersonal communication are laid in the early years as infants gain self knowledge and form satisfactory relationships with others. The role of infants in early interactions is limited by motor constraints and they are dependent on caregivers to initiate communication and interpret affective state from facial expressions and undifferentiated movements. Caregivers respond intuitively to young infants and social interactions permeate daily routines. These interactions are enjoyable for infants and conditioned response patterns develop by three to four months. Communication intent increases as infants develop physiological stability and gain motor control bringing with it changes in the form and use of interaction patterns as summarised in Table 1.4. adapted from assessment protocols devised by Coupe & Jolliffe (1988).

Table 1.4. Development of intentional communication

Months	Intent	Use	Form
0-1	Pre-intentional	Reflexive	Unconditioned affective
2-6	Pre-intentional	Reflexive	Conditioned affective
6-8	Intentional	Proactive	Concrete signs
8-10	Intentional	Proactive	Primitive signs
10+	Intentional	Conventional	Complex signs
12+	Intentional	Conventional	Verbal signs

Infants, from four months, actively seek out opportunities to interact with others. They show awareness of turn taking in imitation and sound making games. Skills developed in these routines are gradually used to serve communication functions and by six months, vocalizations and gestures are used to obtain and direct adult attention. The six to nine month period shows increasing use of primitive forms to serve intentional communication.

Increased motor ability, the development of protophonemic categories, goal orientated imitation and increased socialisation result in a marked increase in sound making. Vocalizations show a wide range of consonant and vowel sounds in multi syllabic babble patterns with varied intonation and stress patterns. These patterns enable caregivers to reliably identify requests and affective meanings from the differential vocalizations of eight month old infants (Negri, 1992). Intentional communication is evident in both gesture and vocalization patterns by nine months (Coupe& Jolliffe, 1988). Gestures, language specific babble and intonation patterns serve an increasing range of communication functions while the formal components of speech are being mastered.

Receptive language

Infants show increasing recognition of words associated with routines and enjoyment in listening to familiar speech sequences from eight months onwards. The developing phonological knowledge base enables the infant to focus on words and word shapes and understanding of spoken language begins to be evident.

Understanding of spoken words is gradually freed from routines and context. The infant begins to recognise his or her name at four to five months and shows recognition of familiar words in connected speech by eight months (Jusczyk & Aslin 1995). Further studies by Jusczyk & Hohne (1997) indicated that familiar words used in these experiments were retained for two weeks. Receptive vocabulary develops rapidly when the link between spoken word as symbol for objects and events is established and studies indicate that children at twelve months understand an average of 86 words (Fenson, Dale, Reznick, Bates, Thal, & Pethick, 1994)

Expressive language

The affective non-linguistic communication of infants begins to move towards verbal communication with the emergence of language specific babble patterns between six and eight months. The recognition of perceptual magnets may contribute to the increase in range and type of vocalizations seen at this stage. Vocalizations show a wide range of consonant and vowel sound, variations in prosodic structures and syllable reduplication. Direct and delayed imitation of sound sequences increases. Infant babble shows variation in patterns of favourite phonemes and syllable structure.

Native language preference appears gradually in infant vocalizations between nine and ten months with the drift initially evident in prosody, followed rapidly by phonemes and finally by syllable structures and word forms (Dodd, 1995; Kent, 1992 b). Phonetically consistent forms and protowords appear in babble and vocalisations. These word forms link babble to speech by reinforcing the role of vocalisations in interactions (de Boysson-Bardies & Vihman, 1991; Halliday, 1974).

By the end of the first year, the representational, cognitive and motor systems are ready to use verbal language and infants begin to use words to communicate intentionally with others. Neural developments during this period show increases

in synapses and the development of intra-cortical connections. By nine to twelve months increased activity is reported in the frontal lobe indicating possible internal reorganisation to accommodate the accumulated knowledge of the infant. This internal reorganisation coincides with the move from object to referent in communication.

Language development is sustained by satisfactory interaction and identification with adult members of the community. Motivation to communicate is enhanced by self awareness and the need for self assertion and the experience of satisfactory interpersonal interactions during the early learning period.

b. Steady: Approximate age range: 12-18 Months

The infant at twelve months is an active intentional communicator, dependent initially on concrete signs and gestures to convey meaning but physically and cognitively ready to transfer to the use of abstract signs and linguistic symbols.

Neuromuscular control

Infants at twelve months have developed voluntary control of a basic range of lip, tongue, velum and jaw movements for eating and drinking. Variations in the developmental rate of the tongue and mandible movement required for a mature swallow pattern are common. Minor variations in early development do not appear to greatly influence the developing speech system. Severe disruptions to early feeding or the persistence of immature patterns may impinge on phonetic aspects of later speech.

Motor control for speech production develops primarily through speech and infants during this period show increases in both the amount and range of vocalizations. There is an increase in jargon, babbling, imitation and naming both in interactions with others and during solitary activities such as the pre and post sleep crib monologues.

Perceptual and cognitive skills

The development of auditory and visual perceptual skills accelerates during this period with active exploration of the environment. Attention skills develop as the infant learns to inhibit irrelevant environmental stimuli and focus selectively on known or novel elements. Play and object use indicate increasing knowledge of means end relationships and categorisation by use, location and class. The development of object permanence frees objects from context and creates the need for abstract representations that serve as a base for linguistic symbols.

The development of categorisation skills and object concepts provides an abstraction mechanism, which supports the further development of memory skills. Infants show the ability to hold verbal items in memory as they listen to instructions and participate in routines and games. They retain knowledge of people, objects and events in memory for longer periods.

Changes in imitation skills are evident as infants begin to imitate the goal of an action rather than the movement patterns (Meltzoff, 1995). Findings from current neuroimaging studies support the importance of goal focussed imitation in learning (Schwartz, 2000). Imitation by goals allows the developing child to adapt observed patterns to his or her own motor capabilities. Goal focussed imitation is reflected in speech as the child moves away direct imitations focussed on the form of utterances to reduced imitation based on semantic content or phonological restructuring.

Receptive language

Receptive vocabulary shows rapid accelerated growth during this period. The number of words increases from a base of approximately 80 to 300 plus by eighteen months. The infant focuses on semantic based learning and a decline in interest in phonetic detail has been noted (de Boysson-Bardies et al., 1996). Werker (1999) suggests that the reduced attention to phonetic detail facilitates a holistic word learning pattern which lasts until the development of referential understanding.

The infant becomes less dependent on contextual cues to aid understanding of speech. This is seen in enjoyment in listening to speech, an increased ability to follow instructions and a developing ability to recognize and interpret speech directed at others. Syntactic comprehension develops and the child shows understanding of relationships between objects, actions and agents expressed in simple sentences.

Expressive language

The first words appear in babble and speech play around the first birthday and vocalisations begin a drift from monologue to dialogue. These may be single words, or formulaic phrases, that encode familiar objects, events and routines. Infants use words intentionally to communicate with others and are reinforced by the affective and physical responses of caregivers. First words tend to be variable in form and inconsistent in usage until the child establishes a base expressive vocabulary of 10–20 words. The first words label objects and events for the child and those in the immediate environment and are used by the child to obtain attention and objects. They are also used to direct the attention of others to object and events in the environment.

New words are gradually adopted into the functional communication system. These words tend to be learned as whole word shapes and there is some evidence that children actively seek new words with familiar phonemes and syllable shapes and avoid producing difficult phonological forms (Dodd, 1995; Fowler, 1995; Ingram, 1989). Word realizations show simplification of syllable structures and wide phonetic variability (Grunwell, 1982; Vihman, Ferguson & Elbert, 1988). The expressive phonological system is not active during this period (Ingram, 1989).

During the next six months, the number of words the child uses to communicate increases gradually. The words frequently show semantic under and overextension thus requiring the use of intonation, jargon, gesture and facial expressions to clarify meaning. Children who have acquired an expressive

vocabulary of approximately 50 words, and who have experienced success in using these words to communicate, progress into a stage of accelerated vocabulary growth associated with the development of a systematic approach to the form of their native language. They have developed the foundation knowledge and skills necessary for speech processing and production. These skills are summarised in table 1.5

Table 1.5. Aspects of speech processing

Element	Factors and functions
Input 1	Environmental stimuli: Smells, Sights, Sounds, Speech Communication context: Physical, People, Objects, Functions
Perceptual filter	**Perceptual filter** actively selects relevant material from sounds accompanying objects, events and actions in the environment
Input 2	**Representational connections:** Speech sounds and sights via auditory and visual modality modalities
Organiser	**Short term memory:** Meaning seeker holds input briefly for processing or rejection. **Referential connections:** Selects relevant data from memory to achieve perceptual unity and pass on for processing
Primer	**Selection** of relevant non linguistic and linguistic knowledge to match input. Prime central processing style e.g. analytic versus gestalt to allocate resources as demanded by the context
Central processor	Comprehension **Inferential decoding** Via long term memory Linguistic decoding **Via verbal representational system** Communication intent Semantic response planner Selection of output: Linguistic / non- linguistic Response formulator Selection and ordering of meaning units, lexicon utterance frame, phonemic plan, phonetic plan **Language** **Lexicon** **Syntax** **Morphology** **Phonology** **Pragmatics**
Output	**Motor plan - Transmission - Execution**
Feedback	**Feedback from self and listener**

The table is arranged serially from input to output, but is not intended to be a processing model as indicated by the nebulous depiction of the representational system and the presence of many explosions indicating potential network interactions and feedback systems.

c. Go: Approximate age range: 18-48 Months

The pragmatic skills and receptive lexical store accumulated during the previous stages provides the child with a foundation for further development of the language system. Development in the final stage of early language can be divided into two phases. During the first phase, understanding of the rules that underlie the formal aspects of language develop. Expressively, the child begins to rely increasingly on single words and word combinations to communicate meaning and serve a wide range of communicative functions. The development of language content, form and use during this period is facilitated by the increasing physical and social independence of the child. Neural organisation is accelerated and metabolic activity increases in all cortical areas. Neuromuscular development reduces motor constraints on speech production. Cognitive constraints decrease as categorization and memory systems are facilitated by the developing language system. Motivation to communicate verbally increases as the child identifies with, and asserts his or her identity to, members of the community.

Receptive language 18-24 months

The understanding of words increases rapidly during this phase and while object names predominate, actions, locations and descriptive words are understood, indicating awareness of relational meaning. Understanding of syntactic structures increases and the child can follow statements containing two to three information carrying units, answer simple questions and follow simple instructions.

Expressive language

A gradual growth in expressive vocabulary is seen as the child moves from the early 50-word level to approximately 100 words. Frisch (1996) suggests that these early words provide the child with knowledge of word form and frequency. This knowledge can then be used to develop the abstraction and categorisation abilities that facilitate later vocabulary acquisition. A period of rapid vocabulary development follows, which has been labelled the 'vocabulary spurt' (Bloom 1993). The vocabulary spurt occurs around eighteen months and is indicative of

cognitive, pragmatic and linguistic readiness for formal language. Delays in the vocabulary spurt may indicate a lack of cognitive maturity (Mervis & Bertrand, 1995). Vocabulary development at this stage is highly predictive of syntactic development in the formal developmental period (Bates, Thal & Marchman, 1989).

Word combinations

Early word combinations begin to emerge when the expressive vocabulary reaches a stable level between 50 and 100 words (Bates et al., 1989; Fenson et al., 1994). These early combinations show an understanding of relationships between agents, objects and actions, between objects and location and between objects and attributes but mark these by adjacency or context. Syntactic markers are not present. The early word combinations are used to obtain and refuse attention, to name and obtain objects, and initiate actions and to maintain verbal interaction with others.

Early word combinations may be seen as precursors of later syntactic development and are measured as such in many studies which utilise mean length of utterance scores (MLU) based on Brown's Stages (Brown, 1973). Others would hold that there is discontinuity between the early form and later syntax. Bickerton (1984, 1996) proposed that this stage should be termed Protolanguage to stress discontinuity between the form of early word combinations and the abstract syntactic form of representational language. The label captures the content and use of language at the early word combinatory stage, and a study by Radford (1990) indicated that it described the form of utterances used by children between eighteen and thirty months.

Protolanguage shows a limited vocabulary with over and under-extension of semantic concepts. The vocabulary is restricted to objects and events in the environment. Function words, which serve as grammatical markers and lexical enhancers in formal language systems, are not used. Table 1.6. summarises the

features that distinguish protolanguage from language as a systematic representational code.

Table 1.6. Protolanguage and formal language

Content & Form	Protolanguage	Formal language
Utterance length	Short	Infinitely long
Rate	Slow with pauses and reformulations	Fast and fluent
Lexicon	Limited	Unlimited
Word type	Generic	Multi
Token type	Referents for objects and events	Referents to enforce structure
Verb arguments	Not expressed or recoverable	Expressed or recoverable
Function words	Not used	Used
Word order	Variable	Fixed
Phonology	Variable	Systematic

Protolanguage is used for direct communication in a limited number of situations. It does not serve the same functions as a representational system and topics are limited to 'what I feel rather than what I know' (Bickerton, 1996:13). The use of protolanguage is reinforced by extrinsic rewards which may maintain motivation to master the verbal code. The use of restricted forms allows the child to use the increased lexicon and experience the combinatory power of words as symbols for abstract communication. The developing lexicon supports and enforces systematic change in the organizational rules of the language system.

Formal language 24-48 months

During the final period of early language development, the knowledge and skills developed in all domains of language integrate and merge to allow the formal representational linguistic system to emerge. Language allows speech to move beyond routine communications and direct object to symbol relationships. Arbitrary abstract symbols break the link between word and action and facilitate the development of offline thinking. Word meanings are enriched by grammatical frames and move beyond direct symbol referent relationships to the arbitrary symbols of secondary representation. There is increasing pressure on the child to move towards the conventional language system of the environment.

Receptive language

Vocabulary and syntactic comprehension show accelerated growth and change during this period. The development of secondary representation provides symbols to develop semantic categorisation and classification skills, which facilitate the development of the processing, retention and recall of new words. The large vocabulary of the two year old refocuses attention on the contrastive role of speech sounds. Phonemic contrasts need to be established to differentiate new words in output for communication and semantically to facilitate retention and recall. Phonological, morphological, and syntactic systems develop to sustain the developing lexicon and representational system. Accelerated development is seen in all components of language form between twenty-four and thirty months (Fenson et al., 1994). The child at two can discriminate between phonemes in words, recognise changes in word meaning due to morphological changes and understand increasingly complex phrase, clause and sentence structures. These changes are seen in the systematic expansion of expressive language.

Expressive language

The development of arbitrary verbal symbols enables children to move from the context bound communications of infancy to abstract verbal language. This development is fostered by an increase in the range and type of communication opportunities and demands that accompany the increased physical and social independence the two year old child. New vocabulary transfers rapidly from receptive to expressive use and words adopted into the lexicon are modified, and modify the developing phonological system. Development of vocabulary and of the phonological, morphological and syntactic components of language form contributes to rapid changes in speech intelligibility.

Intelligibility

Broad based studies of verbal language development indicate that children are expected to develop speech that is intelligible to unfamiliar listeners by the age of four years. Information on developmental stages or norms during this period is limited due to methodological difficulties in studying early communication.

Intelligibility is influenced by many factors and is best viewed as the product of speaker listener co-operation and interaction within a communicative situation. The communications of young children are frequently context linked and the removal of contextual cues in some studies may result in loss of ecological validity. Cognitively and socially young children assume that adult listeners share their knowledge base and have a responsibility to interpret meaning. Listeners also vary greatly in their ability to extract meanings from speech and studies frequently show low inter rater reliability. Percentage increases in intelligibility in typically developing children as judged by unfamiliar listeners are summarised in table 1.7.

Table 1.7. Development of intelligible speech

Age level	Weiss & Lillywhite (1987)	Hodson 1992
2.0 years	26% - 50%	
2.6 years	51% - 70%	
3.0 years	71% - 80%	
3.6 years	81% - 90%	
4.0 years	100%	95%

Intelligible speech is dependent on the use of an agreed inventory of sounds, the application of agreed rules to govern the sequencing of sounds to form syllables and words along with the use of context appropriate syntactic rules. Gains in intelligibility can be attributed to systematic changes in phonology, morphology and syntax combined with increasing motivation to communicate and increasing demands for verbal communication by wider social networks.

Phonological system development 18-48 months

Children acquire the major features of phonological system of the ambient language during the first four years of life. They are expected to say their first words by their first birthday, to be intelligible by their third birthday, and to have clear speech as they begin school around the age of four. Developmental markers in the expressive phonological system are outlined below. These markers are

interpreted in a variety of ways to support the various theories outlined in table 1.3.

i) Phoneme inventory

Research findings on phoneme acquisition are frequently used to identify developmental levels. A review of developmental literature indicates that this can only provide a global measure, as there is a wide range in the ages reported for phoneme acquisition (Dodd, 1995; Edwards & Shriberg 1983; Grunwell 1997; Haelsig & Madison, 1986; Shriberg 1992). The ranges reported are illustrated in figure 1.5. The variations in age levels may be accounted for in part by differences in approaches to data collection with earlier researchers setting a criterion level of 100% correct production and later studies exploring the influence of syllable structure on realization and accepted allophonic and dialectal variations.

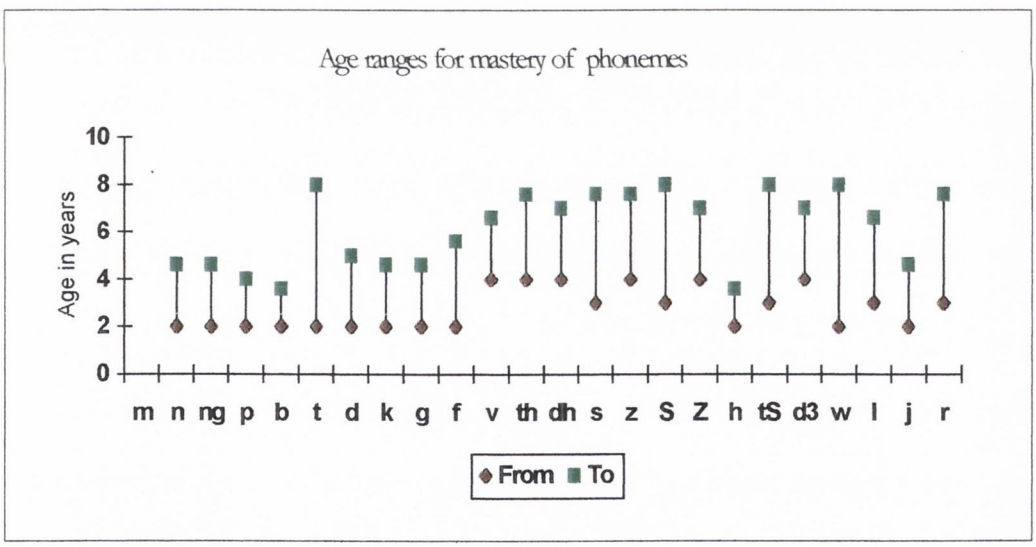


Figure 1.5 Age ranges for acquisition of phonemes

(IPA Symbols replaced as follows: ŋ = ng; θ = th; ð = dh; ʃ= S; ʒ = Z; tʃ= tS; ch; dʒ = d3 and ɹ = r)

Developmental levels based on phoneme inventories allow broad comparisons between levels achieved by children at different ages and between typically developing children and those who are presenting with speech impairment. The value of such comparisons is limited due to the wide variation reported in the

studies cited above. Phoneme inventories provide information on the sounds available to children to use in speech but do not indicate how these sounds are used systematically.

Those seeking to explore how a child acquires the rules of the speech sound system have sought to identify patterns underlying phoneme usage. Many approaches have been used to unify data across feature, syllable and word levels but the approach that has generated most developmental data in recent years has been phonological process analysis based on Stampe's theory of Natural Phonology.

ii) Process analysis

Phonological processes are used to describe the observable strategies used by children as they move towards the native adult system. Process analysis allows speech sound changes to be explored and categorised across individual phonemes, syllable structures, and word position and are used to 'reveal linguistically significant generalisation within and among speakers that might be missed at the phoneme or the feature level' (Shriberg, 1994:1139). During development, the child eliminates or suppresses the processes that are not relevant to the language being learned. Suppression is frequently gradual with the influence of the process bring restricted to a decreasing range of features or sound classes but it can occur rapidly in time. The emergence and suppression of affrication over a three week period in a typically developing child at 2.4 years illustrates these changes. He began to use fricatives instead of all plosives and glides (retaining place of articulation) over a four day period. He retained this pattern for a week when suppression began with stops and glides emerging over two days and stabilising after four days. Affrication of /w/ showed gradual suppression over the following two weeks. Changes such as these may be missed in developmental studies which are frequently based on monthly sampling. Process suppression peaks within the final period of early language development.

The main processes identified in studies of developmental change are described in appendix 1.1. The age ranges for suppression of developmental processes in typically developing children are illustrated in figure 1.6 based on a review of studies by Dodd, 1995; Grunwell, 1985; Hodson, 1994; Howell & Dean, 1994.

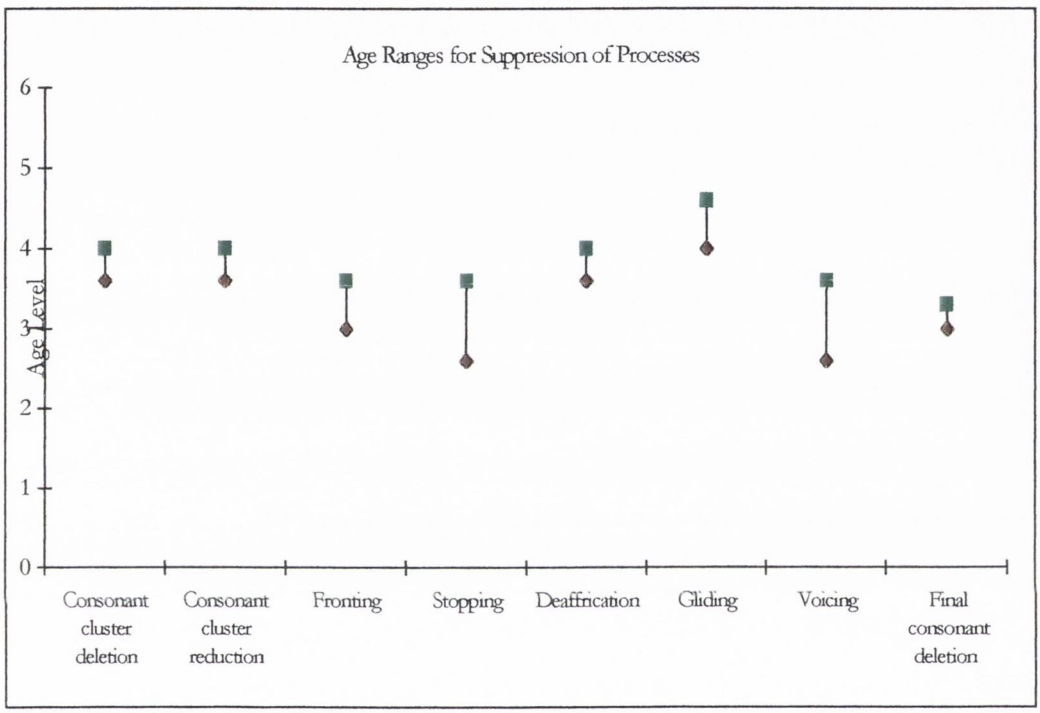


Figure 1.6. Age ranges for suppression of processes

Developmental data on the age of the suppression of processes by typically developing children is incomplete but current findings indicate that most are suppressed or limited in strength by the end of the early language development period. The majority of researchers would agree with Hodson's statement that 'Phonological simplification processes are rare in the utterances of normally developing 4 year olds, and omissions are virtually non existent in their conversational speech.' (1994: 6).

iii) Constraints and ranking

Optimality theory proposes that all language learners begin with a grammar in which constraints against marked structures outrank faithfulness constraints (Markedness constraints dominate Faithfulness constraints). This grammar is

universal and produces maximally unmarked forms resulting in outputs differing from inputs. The language learner's task is to promote the constraints required to be faithful to the ambient language above the universal markedness constraints. Constraint reranking is motivated when the grammar recognises that the optimal output previously assigned to a word does not match the input. Reranking demotes constraints minimally until the correct ranking is achieved and an optimal output is produced (Boersma, 1998). Developmental patterns are evident in changes in constraint rankings as the child's output moves towards the mature patterns (Gnanadesikan, 1995; McCarthy & Prince, 1994; Prince & Smolensky, 1993; Smolensky, 1996 b; Tesar & Smolensky, 1996).

There have been a small number of studies using frameworks from Optimality Theory to explore developmental patterns using connectionist modelling (Boersma & Hayes 1999, Pater, 1997). Studies by Levelt & van de Vijver (1998) identified developmental pathways in syllable acquisition by Dutch children. Children progressed from consonant - vowel (CV) syllables to complex CCVCC along two learning paths:

A CV > CVC > V > VC > CVCC > VCC > CCV > CCVC > CCVCC

B CV > CVC > V > VC > CCV > CCVC > CVCC > VCC > CCVCC

These pathways showed significant correlations with the frequency of syllable types in the ambient language.

Gnanadesikan (1995) analysed data obtained from her daughter from the age of 2.3 to 2.9 years. The results supported a single lexicon model with segmentally accurate underlying forms and an acquisition process in which faithfulness constraints were gradually promoted above markedness until outputs matched the mature grammar. The acquisition process allowed for inter-child variation as the order of promotion of faithfulness constraints can vary.

These studies provided support for the proposal that language learners begin with a universal grammar in which constraints against marked structures outrank faithfulness constraints. In addition, they provided evidence of gradual constraint reranking as learners promote the constraints required to be faithful to the ambient language above the universal markedness constraints. Developmental patterns including overgeneralization and error correction are evident in changes in constraint rankings as the learner moves towards the mature language system (Gnanadesikan 1995; McCarthy & Prince, 1994; Prince & Smolensky, 1993; Smolensky, 1996a, b; Tesar & Smolensky, 1996). The theory allows the acoustic and articulatory phonetic properties of the presenting phonological patterns to be explored.

The potential of Optimality theory to model and explain patterns of phonological development and impairment in children has been shown in studies by Barlow and Gierut (1999), Barlow (2001), Bernhardt & Stemberger (1998) and others. The framework provided by the theory captures speech patterns found in children with phonological disability. It allows correlated error patterns and associations with structural and perceptual characteristics to be explored and used to determine therapy goals. Optimality Theory is currently being used to explore variation in many aspects of language content, form and use has the potential to add new frameworks and approaches to diagnosis and therapy for children with phonological impairment and associated difficulties in other components of language.

Development of morphology and syntax

Development of the phonological system is accompanied by rapid growth in morphology and syntax. In the brief period between thirty and forty months, the majority of children develop the basic rules for combining words into phrases, clause and sentences. They show understanding and use of morphological rules to modify word meanings. By four years, typically developing children understand

and use a wide-ranging vocabulary and have mastered the basic syntactic and morphological components of their native language. They use words and the combinational rules of morphology and syntax to talk about the past, present and future. Their phonological systems allow them to be understood by members of the speech community. Their achievements are summarized in table 1.8.

Table 1.8. Early speech development

Stage	Systematic change	Speech markers
Ready 0 –12 months	Receptive shift phonetic to phonemic: Rote to rule Expressive affective to phonetic goal directed sound making Reflexive to proactive communication Object to symbol	Differential affective vocalizations Sound imitation – babble - differential native language babble - consistent sound patterns - word forms
Steady 12 - 18	Receptive Phonemic to Lexical development Word to Syntactic comprehension Primary to Secondary representational system	Fixed vocabulary; Interaction Vocal / gestural communicative signs
Go 18 - 24 24 - 48	Accelerated vocabulary growth Reference to relational meaning Functional communication from words to word combinations Development of language form	Expressive vocabulary spurt Protolanguage Systematic development Rule to rote in phonology, morphology and syntax

The foundations of the language system are in place by the age of four years. Interactions between the components of language are evident at this stage with developments in lexicon influencing phonology and the phonological system influencing the words that are learned and used.

The development of syntax and morphology facilitates and is facilitated by semantic development (Bates, et al., 1998). Life experiences and learning continue to expand the lexicon. Lexical expansion results in periods of semantic reorganization facilitated by language form. Semantic development will in turn influence developments in language form. Changes in syntax and morphology will be motivated and facilitated by the increasing pragmatic and mathetic demands made on the linguistic system of the developing child, adolescent and young adult. Communication opportunities and environmental experiences will influence the development and integration of all components of the verbal code of language.

1.5 Speech Impairment

Intelligible speech is dependent on the use of an agreed inventory of sounds, and the application of agreed rules to govern the sequencing of sounds to form syllables and words, along with the use of context appropriate syntactic rules. Low speech intelligibility is associated clinically with phonological impairment. Impairment of the phonological system compromises the efficacy of speech as a channel for language. This has the potential to impact negatively on the development of the verbal language system as a whole and on the development of the person as a communicator in society. This section outlines approaches to the identification and classification of phonological impairments.

Phonological impairment

There is little consensus on how speech impairment can best be described, classified or defined. Current clinical approaches reflect the wide range of theories and frameworks outlined in the previous two sections and in addition show influences from medical and social models. Phonological impairments are diagnosed when there is disparity between an individual's phonological system and that required by the ambient language. The degree of disparity is measured primarily by the use of age related criteria in developmental impairments, and by comparison with broad based evaluations of language competence in acquired impairments for the purpose of service provision. The disparity is studied in detail by clinicians in order to explore the nature and causes of the impairment.

Speech impairments can be classified on a structural – functional axis with those that show significant divergence from the norm in oral or neural anatomy or physiological functioning differentiated from those where there are no evident causative, physical or neurological features. They may also be classified by time of onset with those which occur during the typical timeframe of language acquisition termed developmental, and those which impact on a developed system classified as acquired. This review will focus on the classification of functional

developmental impairment of the phonological system. This allows for the recognition of transactional relationships between the motor and representational components of the developing phonological system but excludes motor speech disorders associated with neuropathology.

Many terms are used to classify developmental phonological impairments. These may be linked to theoretical approaches to language or learning but are frequently used as synonyms in the literature. Table 1.9 summarises approaches to speech impairment with terms frequently used as synonyms in bold.

Table 1.9 Summary of approaches to speech impairment

	Labels	Causation	Diagnosis	Therapy
Objective Form	Articulation defects/disorders **Speech disorders**	Structural or functional physical /emotional Faulty learning	Observable structure and functioning Phonetic units	S-R learning of sounds
Abstract form	**Developmental speech disorder** **Phonological delay /disorder**	Neurolinguistic dysfunction Inadequate triggering or learning	Rule and features underlying surface errors Phonemic units	Learning of rules System based Conceptual focus
Reality rooted abstract form	Speech disability **Phonomotor disability** Phonological disability	Restrictions Perception / on learning of ambient language form	Phonological rules and processes Process as unit	Suppression of universal processes – system based
Interactive systems	Phonological impairment Articulation impairment	Underlying deficits in sub systems or processes	Phonology as part of language system. Identification of strengths/deficits Miscellaneous units	Broad based deficit approaches
Connectionist	**Expressive phonological impairment**	Learning algorithms- incorrect weightings Insufficient experience	Identify current system, stage and processes	Variety of systems and key elements.

The term impairment is used in this study in preference to disorder, as it does not imply a clinical entity with defined causal factors (ICIDH-2, 2000). Linguistically,

the term impairment is preferable to disorder which implies a lack of structure or order. Research has indicated that systematic rules operate in impaired phonological systems.

Characteristics

Phonological impairments are characterised by a failure to apply the phonological rules of the ambient language when speech is used as a channel for interpersonal communication. The diagnostic criteria for phonological disorder in the *Diagnostic and Statistic Manual of Mental Disorders* (DSM-IV: 2002: 315:39) includes

> 'Failure to use speech sounds that are appropriate for age and dialect...
>
> Difficulties in speech sound production interfere with academic or occupational achievement or with social communication
>
> If mental retardation a speech-motor or sensory deficit, or environmental deprivation is present, the speech difficulties are in excess of those usually associated with these problems'

These criteria are of limited value when the constraints on knowledge of phonological development outlined in previous sections are taken into account. They are of less value when applied to the population of interest in this study. Many children and adults with Down syndrome would be excluded from this diagnosis on the basis of their general learning difficulties (mental retardation).

Clinically, phonological impairments have been classified by description of linguistic features and the identification of causal factors in anatomical structures and in physiological and cognitive-linguistic functioning.

Linguistic features

Phonological impairments are classified linguistically in clinical settings by the analysis of speech samples to identify the individual characteristics and organisational patterns. This approach allows the analysis of individual phonologies as autonomous functional systems and, in addition, allows comparisons to be made between the impaired system and the target language system. Comparisons of impaired systems with the mature system reveal similarities in phoneme inventories and operational processes. They also reveal differences in the following linguistic characteristics:

a.) Variations from the phonemic inventory of the target language in

- Quantity: Reductions in phoneme number
- Type: Use of a phonemic inventory atypical of the language
- Quality: Differences in phonetic realisations of phonemes

b.) Variations from the rules of the phonological system of the target language

- Quantity: Mismatch between number and strength of rules / processes / rankings required
- Type: Application of inappropriate rules, processes, or rankings
- Quality: Inconsistent or variable rule / process application

Impaired phonological systems are described and classified using a range of measures including severity rating, and estimates of developmental or relational status of phonological inventories, processes, rules and constraint rankings. The degree of impairment is classified qualitatively by labels such as 'mild' and 'moderate' or quantitatively by direct number or percentage ratings.

Phoneme inventory

The majority of infants can produce the full range of speech sounds required for the ambient language and begin to use these contrastively to signal meaning in speech by the age of two years. The transfer from phonetic to phonemic competence occurs rapidly and with variation in order in typically developing children. By the age of four, the phoneme inventories of typically developing children approximate those of the ambient language. Any reduction in the number of phonemes will decrease the range of contrasts available to the speaker and contribute to homophony and loss of meaning (Ingram, 1989). Developmental levels based on phoneme inventories allow broad comparisons to be made between typically developing children and those who are presenting with speech impairment. The value of such comparisons is limited due to the wide variations outlined in the previous section. Qualitative analysis of phoneme inventories may identify specific patterns indicating difficulties with place or manner of articulation.

The use of non ambient language sounds as phonemes will result in non functional contrasts and listener confusion. Atypical phonemes may reflect compensatory responses by the speaker to structural constraints on the speech mechanism, as can be seen in the increased use of glottal place of articulation in infants with cleft palate. Differences in phonetic realisations of phonemes such as de-aspiration or broad tongue palate contacts may impair intelligibility if the allophonic realisation forms the phonemic core. Phoneme inventories provide information on the sounds available to children to use in speech but do not indicate how these sounds are used systematically.

Percentage of consonants correct

Measures of percentage of consonants correct (PCC) are used to calculate the contrastive use of consonant phonemes in speech. These may be based on spontaneous or elicited speech samples. They are calculated using a variety of methods ranging from a direct count as correct of all productions consistent with the target language system to differential scoring of error types and contexts such as those developed by Shriberg and associates (1994, 1997) for the *Speech Disorders Classification System.*

Phonological processes

Process analyses identify the organisational patterns of the phonological system. Phonological processes are suppressed rapidly during early language learning and the persistence of processes beyond the age of four is one of the defining characteristics of phonological impairment. Speech samples are analysed to identify the number and type of processes active. These can then be compared to patterns reported from typically developing children. The level of analysis can vary from identification of the presence of a limited number of language specific processes to analyses that utilise a broader universal language approach. Table 1.10. lists the developmental processes, which were found to occur with greater frequency in the speech of children with phonological impairment (Crary, 1993; Grunwell, 1997; Stoel-Gammon & Dunn, 1985). They have been divided into two columns with those in the atypical column rarely reported in typically developing children (Hodson & Paden, 1981; Weiner, 1981).

Table 1.10. Processes reported in the speech of children with developmental phonological impairment

Process	Typical	Atypical
Final consonant deletion	√	
Initial consonant deletion		√
Unstressed / Weak syllable deletion	√	
Cluster reduction	√	
Cluster deletion		√
Fronting	√	
Backing		√
Glottal replacement		√
Systemic Sound preference		√
Stopping	√	
Voicing /Devoicing	√	
Affrication		√
De-affrication	√	
Gliding	√	

Process analyses allow classification of impairment by the number of active processes, process type and process strength. The use of process analysis in developmental and clinical research has facilitated the identification of subgroups within the population who present clinically with impairment of the phonological system.

The following subgroups have been identified from the larger population of children with phonological impairment:

i). Delayed phonological acquisition (Dodd, 1995)

Phonological patterns observed in this group resemble those of younger children developing speech within the typical time frame. The pattern has also been referred to as persisting normal processes and speech delay (Grunwell, 1997; Shriberg & Kwiatowski, 1994).

ii). Chronological mismatching

The phonological systems used by children in this subgroup show a co-occurrence of earlier patterns and later developing patterns (Hodson & Paden, 1983).

iii). Consistent deviant disorder

The consistent presence of atypical processes or processes that rarely occur in typically developing children indicate a pattern of deviation from the norm s of the ambient language. This group were labelled as 'consistent' by Dodd (1995) to differentiate them from the final group whose systems are characterised by inconsistency.

iv). Inconsistent deviant disorder

Children who show variable application of processes at both phoneme and system level are classified as showing inconsistent systems deviant disorder.

Children who present with speech impairments associated with motoric constraints are frequently seen as a separate from those whose impairment has a cognitive or linguistic basis. Articulation disorders manifest as an inability to 'produce a perceptually acceptable version of particular phones' (Dodd, 1995:54). Specific difficulties in motor planning or execution associated with motor speech disorders may accompany impairment of the phonological system.

Classification by linguistic subgroup has facilitated research to identify associated linguistic and non linguistic behaviours and has provided direction for therapy.

Phoneme inventories and process analyses allow the content and organisational rules of impaired phonological systems to be explored quantitatively and qualitatively but may fail to capture some elements of dynamic organisation of speech as a motor skill and a channel for verbal communication.

Constraints and rankings

Theoretical frameworks based in Optimality Theory have been used in a number of studies of phonological impairment (Barlow & Gierut, 1999; Gierut, 1999). Findings from these studies indicate that the theory facilitates the identification of patterns of development, change and impairment. Markedness constraints allow acoustic and phonetic properties to be explored within the phonological system and facilitate the development of possible explanations for the error patterns seen in phonological impairment.

Tools to identify and classify the linguistic features of phonological impairments are still developing and no one approach can yet capture in full or explain the linguistic patterns seen in those with low speech intelligibility.

Severity Ratings

Severity ratings are used to classify the degree of impairment, handicap or disability present when the phonological systems are restricted. Ratings may be based on comparisons of phonological patterns seen in those with speech impairment with those seen in typically developing children and are frequently reported in terms of mild, moderate, and severe delays. Alternatively, ratings may be based on similarities and differences between the target and impaired systems. Severity ratings provide global estimates of impairment and are used primarily for service management. Clinical measures require detailed information on how the impaired system functions as a carrier of verbal language. Clinical severity ratings tend to be broad based estimates of intelligibility which reflect listener judgements of the functioning of segmental and supra segmental systems in speech.

Aetiology

Explorations of factors contributing to phonological impairment have been pursued using models from medicine and psycholinguistics and while these have identified associated physical, sensory, social and linguistic factors they have not yet achieved explanatory power.

Associated factors: general

Studies using linear models of causation have sought to establish correlations between phonological impairment and physical, cognitive and social factors. Many perceptual, organisational and production factors have been associated with phonological impairment but consistent correlational patterns have not been established (Gierut, 1998). Factors such as family history, otitis media, feeding difficulties and thumb sucking have all been explored with inconclusive results (Friel Patti, 1990; Hensel & Splieth, 1998 cited in Fox, Dodd & Howard 2002; Lewis & Freeborn, 1997; Pagel-Padden, 1994). The use of databases such as the *Speech Disorders Classification System* (SDCS) developed by Shriberg and his associates (Shriberg & Kwiatkowski, 1994) has facilitated data collection on large groups of children with phonological impairments over time. The SDCS collects information based on evaluations of presenting phonological profiles and aetiological factors and has provided detailed information on developmental trends (Shriberg, Austin, Lewis, McSweeney & Wilson, 1997; Shriberg, Kwiatkowski & Gruber, 1994). Information from the database has been used to identify possible diagnostic markers for subtypes within the population with phonological impairment (Shriberg, Aram, & Kwiatowski; 1997).

The nature of developmental impairments restricts use of classification systems such as the SDCS and the *Data Analysis for Speech and Language Therapy* (E.H.B., 1995). Developmental impairments frequently show changes in observable form over time and the developmental time frame allows new associated factors to emerge and replace or accompany those initially identified. In addition, classification systems frequently fail to identify the combinations of minor factors which clinical studies have identified as influencing the severity, developmental trajectory and the prognosis of phonological impairments (Hodson, 1994). Classification by aetiology provides useful data on client groups and tracks changes over time. It does not provide detailed information on the linguistic aspects of the individual impairment.

Associated factors: psycholinguistic

Psycholinguistic models have been primarily used to identify patterns of deficits and strengths in many aspects of the language system. Models such as those of Dodd (1995) and Stackhouse & Wells (1997) have facilitated the development of detailed clinical assessment procedures. The identification of specific deficits in components of the processing system, which could be associated with linguistic features, has broadened the range of therapeutic goals and techniques. The majority of studies using these models have focussed on detailed individual assessment and case reports. Their use in exploring the nature of phonological impairment during early language development has been limited.

Studies by Dodd (1995) identified associations between specific deficits in processing and those classified by linguistic features. Dodd (1995:56) proposed that 'the presence of unusual processes signals an impaired understanding of their native phonological system' in those who present with consistent deviant disorder. Experimental findings supported this, in that members of this group showed a lack of preference for the legal structures of their language. The group with inconsistent deviant disorder showed deficits in receptive and expressive vocabulary and phonological planning (Dodd McCormack, & Woodyatt, 1994). A later study by Lietao, Hogben and Fletcher (1995, cited in Dodd, So & Wei, 1996) identified deficits in phonological processing skills in this group. Psycholinguistic modelling provides a useful framework for the identification of processing deficits associated with phonological impairments and facilitates the development of goal directed therapy.

Associated factors: neurolinguistics

Neurolinguistic theories explore and explain speech impairments by reference to early neurological development. Delays and impairments have been associated with optimal learning periods. The notion of these periods as being critical and

strictly time framed has been modified with increasing knowledge of neurological development, and the term 'optimal' now implies that change is facilitated by combinations of neurological, social, physical and cognitive factors. The optimal period for mastering the representational nature of actions appears to be in full flow in the early neonatal period and may begin to ebb by early childhood. Studies of children with delayed exposure to language systems (both oral and manual) indicate differences in the fluency and accuracy of the end code achieved. Studies of bilingualism and late second language acquisition also indicate that adaptation of both phonemes and phonological system rules pose greater difficulties as adolescence approaches. The foundations of the phonological system appear to be laid receptively in the first year of life and expressively in the second and third. Insufficient input or output during this period may contribute to the development of atypical systems.

Summary

As can be seen from above, the term phonological impairment functions primarily as a descriptive label used to classify speech sound systems, which fail to carry meaning adequately for the ambient language. The prevalence figures for developmental phonological impairments at school entry range in the U.K. and U.S.A. from 2.5 % to 7.5% (Dodd, 1995; Enderby & Phillips, 1989; Enderby & Petheram, 2000; Shriberg & Kwiatkowski, 1994). The linguistic features can be described in detail using phonetic and phonemic inventories. Process and rule based analyses allow additional linguistic features to be identified but these lack explanatory power. Phonological impairments have been associated with factors in physical, cognitive and social domains but causal relationships have yet to be established. There are many gaps in the current knowledge base on phonological impairments, which need to be addressed in order to provide intervention in an effective and efficient manner.

Timely therapy may help to prevent the development of associated difficulties in children who present with constraints on speech as a channel for verbal

communication. Low speech intelligibility at school entry may influence actualisation of social, linguistic and cognitive potential. Findings from many studies indicate that children with phonological impairments have difficulties in the development of phonological awareness and processing skills frequently linked with the development and attainment of age appropriate of reading skills (Dodd, 1995; Hodson, 1994; Stackhouse & Wells, 1997). Adolescents who had presented with speech and language impairment in early childhood showed increased social and psychiatric needs during the teenage years (Cohen, Davine, Horodezky, Lipsett & Isaacson, 1993 cited in Hodson 1994). Adults with a history of speech impairment were found to have lower status employment and more frequent periods of unemployment.

The integrity and stability of the phonological system in effective communication influences and is influenced, both positively and negatively, by the other systems within language and context. Attempts of speakers with restricted phonological systems to increase morphological, syntactical or representational complexity may stress developing or impaired speech systems and contribute to decreased efficacy in interpersonal communication. Atypical developmental trajectories may develop where protracted periods of language development or specific impairments frustrate the ability of the individual to connect and communicate with others. Changes in developmental trajectories may encourage the creative language system to modify or augment language form to serve interactional needs. The developmental stasis or adapted phonological systems used by those who present with phonological impairments may illustrate the creativity of speakers and language systems in maintaining interpersonal verbal communication.

1.6. 'Good communicators; poor speakers'

This chapter began by outlining the components of communication and explored theories and approaches to speech as a channel for verbal language in order to clarify the concept of 'poor speaker.' Theories and approaches to the study of

language, speech and speech impairment in speech and language and related disciplines were reviewed and indicated that the 'consensus on a descriptive - explanatory framework' sought by Shriberg (1994: 27) has still to be achieved.

The review suggested that current approaches to speech impairment are primarily descriptive and that attempts to arrive at explanation of speech impairment needs to

- Recognise that speech is an output system of language as a representational system.

- Recognise that speech is an output system of language specific content, form and use.

- Recognise that speech is the motor channel for expressing a language and that as such it is open to the influence of phonetic factors.

Children who do not achieve intelligible speech at the expected age level may experience constraints on social, linguistic and cognitive development. The majority of children and adults with Down syndrome experience difficulties in developing intelligible speech with surveys indicating that approximately 90% cannot make themselves understood using speech outside the home environment (Kumin, 1994). The following chapters provide a review of the literature on speech development and impairment in infants, children and adults with Down syndrome in order to identify possible causes for the frequent use of the label 'Good communicator; poor speaker.'

CHAPTER 2

DOWN SYNDROME

DEVELOPMENTAL CONSTRAINTS

Individuals with Down syndrome experience many constraints as they develop, learn and use the spoken language of their communities. Some constraints are congenital and linked to the extra genetic material, others emerge developmentally as infants, children and adults with the syndrome adapt to their physical, social and linguistic environments. Some will overcome these constraints to become good communicators but surveys and clinical experience indicate that the majority will experience difficulties in using speech to communicate effectively with others. A survey of parents' views of their children speech indicated that the majority could communicate well in many situations but that articulation difficulties lowered intelligibility for 71-94% of those in the age range 4-21 years (Pueschel & Hopman, 1993). These findings were supported by a larger study by Kumin (1994), which indicated that over 90% of children, and adults with Down syndrome had difficulties in maintaining intelligible speech. The constraints, which may impact negatively on the development of speech and language, are outlined in this chapter.

2.1 Genetic constraints

Down Syndrome is the term used to describe the medical and physical characteristics seen in individuals born with extra genetic material from chromosome 21. Down Syndrome or Trisomy 21 is one of the commonest chromosomal disorders compatible with survival with an estimated incidence of 1:750 live births (Dolk, De wals, Gillerot, Lechat, et al., 1990). The syndrome is variable in presentation and shows no sex bias. Life expectancy for those with the syndrome has increased dramatically during the past fifty years. Life expectancy at the beginning of the last century was 5 years and reached 12 years at the end of the forties (Baird, & Sadovnick, 1988). By the end of the eighties life expectancy was approaching that of the general population with 70% of individuals with Down syndrome expected to live beyond 50 years, 44% to the age of 60 and 13.1% to 68 years (Nicholson & Alberman, 1992). Estimates of prevalence are unreliable due to the changes in age profiles and the fact that many will be unrecorded on data bases following birth.

The majority of individuals with the syndrome (approximately 94%) have standard trisomy 21 resulting from the distribution of an extra copy of chromosome 21 at conception. Standard trisomy 21 is associated with a higher mean maternal compared to the mean for the general population. Many causes for the meiotic error have been proposed but none have been confirmed.

Approximately 3% of individuals with Down syndrome will present with a mosaic pattern where some cells carry two copies of chromosome 21 and others three. This pattern occurs due to errors in early cell division. The proportion of cells with additional chromosome material and consequently the clinical features are determined by the stage at which the error in cell division occurred. The remaining 3% of individuals will have the extra chromosome 21 material translocated on to another chromosome usually number 14 or 15 (Selikowitz, 1992).

The majority of genes on chromosome 21 were identified and indexed by the RIKEN group (2000) and tentative associations with a small number of physical signs and symptoms have been made. Functional links have yet to be established.

Stem cell research has identified underexpression of SCG10 and other genes associated with neuronal growth and plasticity in the Down syndrome neural stem cells. The resultant neurons were smaller in size and number and had smaller twisted neurites. These neurons may contribute to the decreased cell numbers, altered synaptic connectivity and the development of amyloid plaques commonly associated with the syndrome.

Studies using murine models have identified possible associations between cognitive difficulties in the syndrome and the DYRK gene. Overexpression of the gene in mice resulted in severe learning difficulties (Galdzicki, Siarey, Pearce, Stoll & Rapoport, 2001). Studies to identify specific associations between structure and function have found hippocampal and prefrontal cortex dysfunction in mutant mice. The mice showed a significant reduction in spatial learning, reference memory and cognitive flexibility. Working memory was relatively unimpaired (Altafaj, Dierssen, Baamonde, Marti et al., 2001)

2. 2. Physical constraints

The additional chromosome material has the potential to influence all cells and physiological systems but the influence in any one individual will be tempered by overall genetic make up and environmental experience. A review of features associated with the syndrome in infancy by Cicchetti and Beeghly (1990) included congenital cardiac and respiratory defects, immuno deficiencies, seizure disorders, low muscle tone and sensory impairments. A review of features over the life span indicated increased risk of epilepsy and of auditory, visual and neurological impairments at an earlier than their peers without the extra genetic material (Davies, 1996; Haxby, 1989; Wisniewski, Wisniewski & Wen, 1985). Factors

associated with the syndrome, which could reduce opportunities to learn and use verbal communication skills, are summarised in this section.

Structure

Infants with Down syndrome present with a higher incidence of major congenital cardiac and gastrointestinal tract malformations. Minor anatomical malformations, which may have a direct influence on speech, are also more prevalent in this population. These include

- Oral cavity: small size relative to tongue
- Hard palate: extremes in height and width high narrow arch
- External ear and canals; smaller in size
- Narrow low angled eustachian tube

These anatomical signs are not specific to Down syndrome but parallel those found in the general population. Shapiro suggests that the syndrome is characterised 'by their increased prevalence, precocious onset, greater severity, multiplicity and chronicity' (1994: 86).

Skeletal growth and development occurs at a slower rate than in typically developing children. Deviations in the proportional relationships between bone and soft tissue structures emerge during development and may influence early sound making experiences. These include:

- Tongue size relative to the oral cavity may facilitate or hinder the infant in defining the articulatory space, and in learning the range of movements required for speech.
- The development of nasal oral sound contrasts may be restricted by a small soft palate and wide oropharynx.

Late development, smaller size and malocclusions in dentition may deprive the infant of a prominent articulation point during early stages of oral motor learning.

These structural imbalances may restrict early sound making experiences during infancy and contribute to difficulties in motor planning and execution experienced by older children and adults.

Differences in neuroanatomical structures and neurotransmitter functioning have been identified (Courchesne, 1988; Wisniewski, Wisniewski & Wen 1985; Wisniewski, Miezejeski, & Hill 1988, Wisniewski, Kida, & Brown, 1996). These include decreased cell numbers, altered neuronal differentiation, delayed myelination, altered synaptic connectivity and the development of amyloid plaques and neurofibrillary tangles. Amyloid plaques, which are associated with Alzheimer type symptoms in the general population, are diffusely located in the brains of adults with Down syndrome. These plaques have been linked to the overexpression of a gene making amyloid precursor protein, which is located on chromosome 21. Neurotransmitter and protein differences have been found prenatally but there is some evidence that neuron degeneration is accelerated from late infancy by increased generation of reactive oxygen species as the infant copes with environmental stressors and that later structural deviations arise from cumulative damage to the neural system (Cocchi, 1990).

Differences in neurotransmitter production influences dendrite and synapse formation during early development and may contribute to a developmental trajectory which results in differences in brain structure. There has been support from recent imaging studies for earlier speculation of restricted development of the cerebellum, brainstem and frontal lobe (Pinter, Menon, White, Schmitt, Warsofsky, Podchiyska1, Glover, & Reiss, 2002) Preliminary findings from the imaging studies by Pinter and his colleagues (2002) have identified reduced activation in right frontal region, which they associated with perseveration and inhibitory deficits. This area has been associated in previous studies with cross modal representation and imitation. Reduced participation of the frontal regions may contribute to difficulties in the rapid sequential movements required for speech. Difficulties in sequential oral movements have been reported in many studies of speech intelligibility in children and adults with Down syndrome and

have been linked to characteristics of developmental apraxia of speech in a study by Kumin and Adams (2000).

Function

Early language development requires functioning sensory, perceptual and cognitive systems to utilise the learning opportunities provide by their caregivers and the environment. The infancy of many with Down syndrome will be disrupted by critical medical illnesses, hypotonia and sensory impairments. The presence of medical conditions such as congenital cardiac conditions and malformations of the gastrointestinal tract along with an increased vulnerability to infections in the early years may result in the loss of language learning opportunities. Recurrent illnesses and the medications required to survive them may limit the infant's capacity to establish the physiological stability necessary to free resources for perceptual and cognitive development. Specific speech difficulties may also arise where early oral motor learning opportunities are limited or atypical as can occur when nasogastric or intravenous feeding is required and transfer to solids delayed.

Hypotonia

Infants with Down syndrome frequently present with a reduction in muscle tone and associated delays in the acquisition of co-ordinated movements. Low muscle tone in the oral and pharyngeal musculature will constrain the mastery of movements required initially for feeding and affective facial expression and later for speech.

Early sucking and swallowing reflexes may be delayed in onset and persist for a longer period than in typically developing infants. Atypical developmental patterns have been reported in some studies. These include decreased lip activity along with an increase in tongue protrusion in sucking and swallowing, atypical

bite patterns using a protruded tongue and movements of the mandible to break food against teeth and asymmetrical jaw movements (Cullen, Cronk, Pueschel, Schnell & Reed, 1981; 1984; Spender, Dennis, Stein, Cave, Percy, & Reilly, 1995). The emergence of these patterns may be determined by tone in the oral musculature. Kumin and Chapman-Bahr (1999) in a study of oral motor skills related to feeding found differential patterns of hypotonia in infants and preschool children with low tone more evident in the tongue than the lips.

Developmental differences in eating and drinking patterns may restrict early oromotor exploration and limit the development of motor, kinaesthetic and tactile templates, which may contribute to later ease of articulation. Passive tongue protrusion may develop into active protrusion associated with gross motor movements as hypotonia resolves. Studies of articulatory patterns in older children and adults with Down syndrome have found atypical tongue tip movements. Electropalatographic studies by Hamilton (1993) found that tongue palate contact patterns for coronal sounds were broader when compared to a control group without the syndrome. The study also found that the participants with Down syndrome differed in velar articulation and in transition times between consonants in clusters. Difficulties with coronal tongue movements and complex syllable structures will impact negatively on intelligibility in languages which require contrasts between coronal and velar place consonants and between simple and complex syllables. A study by Miller, Miolo, Sedey & Roach, (1994) indicated that early mastery of oral movements may facilitate vocabulary acquisition in infants with the syndrome. This study found positive correlations between oral movements at 14 months and vocabulary at 30 months.

Hypotonia has also been associated with changes in voice quality such as the hoarseness, low pitch and breathiness, which can lower intelligibility in some children and adults with Down syndrome. A study by Pryce in 1994, found that voice production demanded nearly twice as much the energy in the laryngeal muscles from those with the syndrome when compared to a control group with learning difficulties. This difficulty in initiating and maintaining laryngeal tension

may also be reflected in inconsistent voicing / devoicing patterns seen in the phonological system. Reduced tone in the tensor velar palatii may affect the functioning of the eustachian tubes resulting in limited aeration of the middle ear (Diefendorf, Bull, Casey-Harvey, Miyamoto, Pope, Renshaw, Schreiner & Wagner-Escobar, 1995). This could contribute to the higher incidence of recurrent otitis media and the longer duration of hearing loss reported in this population.

2.3 Sensory constraints

Hearing

Children with Down syndrome frequently present with malformations of the pinna, the external canal, the middle ear ossicles and of the eustachian tube. The external ear is approximately two standard deviations below average at birth, growth rate is slower than in typically developing children and the pinna remains smaller than average at maturity (Sando & Haruo, 1990). The external canal tends to be narrow and prone to blockages by cerumen and skin detritus. The craniofacial configuration and skeletal developmental patterns associated with the syndrome may contribute to the higher prevalence of hearing impairment. The anatomical development rate results in the eustachian tube remaining horizontal until adolescence, which may contribute to the persistent vulnerability to conductive hearing loss seen in many children.

Conductive hearing loss

A review of research studies in the nineties indicated that between 70% and 90% of children with Down syndrome experience intermittent conductive hearing loss during the early language learning period (Davies, 1996; Diefendorf et al., 1995; Mazzoni, Ackley & Nash, 1994; Miller, Leddy, & Leavitt, 1999; Selikowitz, 1992, Miller, 1992). These studies also indicated that the frequency, severity and duration of the conductive hearing loss were greater for the children with Down syndrome than for the typically developing children.

Comparative studies of the effectiveness of current surgical procedures for the treatment of otitis media indicated that these were not as effective for the children with Down syndrome as they were for typically developing children (Diefendorf et al., 1995; Iino, Imamura, Harigai, Tanaka, 1999; Selikowitz, 1992). These studies found that improvement in hearing acuity after the placement of tympanostomy tubes was not consistently achieved in children with Down syndrome. They suggested that craniofacial configuration and recurrent respiratory infection may also contribute to the limited success of medical or surgical treatment reported in this population.

Sensori-neural hearing loss

There is an increased prevalence of sensori-neural hearing loss in children with Down syndrome with prevalence estimated at 20% (Roizen, Wolters, Nicol & Blondis, 1993). Prevalence rates for hearing impairment in adults with the syndrome have been estimated at 60% (Davies, 1996)

Hearing impairment at all stages of life reduces the effectiveness of the auditory feedback system used to monitor and maintain speech intelligibility. Hearing impairment during the early language development period, whether sensori neural or persistent intermittent conductive, will deprive infants and children of opportunities to develop the auditory perceptual and conceptual skills that lay the foundations for speech and language. The long term sequelae of early hearing impairment in typically developing children include difficulties in many areas of receptive and expressive language (Friel-Patti & Finitzo, 1990; Roberts, 1997). They are also evident in auditory processing (Gravel & Wallace, 1995) and speech sound perception and production difficulties (Petinou, Schwartz, Mody & Gravel, 1999).

Hearing impairment appears to exert a stronger negative influence on the speech and language of children and adults with Down syndrome. This is borne out by studies which found positive correlations between a history of frequent otitis media in infancy and low speech intelligibility in childhood (Chapman, 1997;

Miller, Leddy and Leavitt, 1999). A similar association was found between communication skills and hearing loss in adults by Haxby (1989)

Vision

Studies have indicated that the visual acuity of the majority of infants with Down syndrome is within typical limits at birth (Woodhouse, Pakemau, Saunders, Parker et al., 1996). Visual reflexes are slower to develop and recognition and gaze patterns show moderate delays (Berger 1990; Courage, Adams, Reyno & Kwa, 1994). Developmental studies indicate that as a group, they are at greater risk of ocular pathology and visual impairment throughout the lifespan. Woodhouse and his associates found that difficulties in accommodation were evident between 3-14 months (1996). Visual defects were found in 77% of school age children (Turner, Sloper, Cunningham, & Knussen, 1990). Reports on the incidence of refraction errors vary from 20–60% with later studies using increasingly sophisticated testing equipment showing the increased incidence. Teenagers and adults with the syndrome are at risk of early cataract development with the incidence of cataracts in adulthood varying from 25-85% (Catalano, 1992).

The slow development of visual reflexes and refraction errors may deprive the developing infant of the visual cues used by typically developing infants as they learn and establish crossmodal representations for speech during the babbling period.

The anatomical and physiological constraints outlined above may deprive the developing infant of opportunities to develop the perceptual, motor and cognitive skills that lay the foundations of language and speech. Persisting constraints and atypical developmental trajectories may contribute to the difficulties encountered by children, adolescents and adults with Down syndrome in achieving and maintaining intelligible speech.

2.4 Cognitive constraints

The physical and sensory constraints encountered by infants with Down syndrome in processing environmental information influence early perceptual and conceptual learning. Many will need a longer period to develop basic strategies for coping with, and learning from the environment. This prolonged period results in variations in time from the typical developmental pathways in early learning and frequently culminates in patterns of mild to moderate cognitive impairment at school entry. Cognitive development during childhood and the adult years continues with major variations in developmental rate and achievements.

Cognitive development is frequently tracked using developmental scales and psychological/psycho-educational assessments which compare the achievements of the subject with those of a normative peer group. Comparisons are made using scores expressed as developmental/intelligence quotients or as developmental/mental ages. These scores identify differences in time of achievement of cognitive markers. Mental age and intelligence quotients are frequently used in studies to explore cognitive achievements in infants, children and adults with Down syndrome. They are also used to match participants in comparative studies exploring developmental differences in language and cognition in populations with varying chromosome patterns.

The information provided by these studies is limited by the time based constructs involved in scoring and by the collapse of a broad range of sensory and information processing capabilities, cognitive knowledge, and response skills into a single measure. Borthwick (1994, 1996) has argued that such measures cannot accurately reflect potential because of lack of construct validity. These measures are based on the assumption that performance mirrors ability and while this may be a valid assumption in the groups on which such measures are normed, it may not hold true for those who experience sensory, physical and cognitive

constraints. His concern is supported by findings of variability in test retest results with children with Down syndrome by Wishart (1998). The children assessed in her studies showed variations in pass/fail performance on up to 30% of test items.

The majority of studies using global developmental measures indicate that infants and children with Down syndrome follow a similar sequence in cognitive development to typically developing children during early childhood, but do so at a slower pace (Dunst, 1990). Studies based on intelligence quotients or mental ages frequently identify declines in quotients or stasis at early developmental levels during childhood. This may be due to the nature of the measures used as the global figure obtained 'denies their specific impairments, and conceals their individual potential' (Borthwick, 1994:12). Broader based studies of adolescents and adults with Down syndrome indicate that learning continues during adolescence and adulthood and a wide range of achievements in language, literacy, social and vocational skills has been reported (Carr, 1988, 1995; Chapman, 1995; Byrne, Buckley, MacDonald & Bird, 1995).

Studies of specific cognitive developmental patterns have greater potential than those based on general measures, such as intelligence quotient or developmental quotient, to identify the cognitive constraints which may influence the development of speech and language.

Perceptual and conceptual constraints

Human learning begins early in uterine life with reflex responses to auditory, visual and other stimuli established. Habituation, the earliest type of learning has been found to be delayed in development in foetuses with Down syndrome, and as infants, they are slower to recognise familiar sound or sights. The ability to ignore persistent stimuli and to focus attention on new elements is basic to learning and difficulties in habituation will influence all aspects of environmental learning. Infants with the syndrome have been found to show a reduced ability to dampen irrelevant material and identify new information (Courchesne 1988).

Reduction in habituation may contribute to delays in inhibiting primary reflex responses and to the emergence of atypical developmental pathways as the infant tries to achieve homeostasis in an ever-changing world.

Discrimination and classification

Infants with Down syndrome experience constraints on the reception of information from the environment. They have been found to be slower to develop recognition of vocal signals, with delays of two to three months reported in recognition of their mother's voice and affective intonation patterns. They are slower to locate and recognise environmental sound sources. Specific difficulties in speech sound perception have been identified and associated with deviations in temporal processing patterns (Eilers, Bull, Oller & Lewis, 1985). Visual development shows a similar pattern of delays in visual discrimination of faces, object regard and visual tracking (Fantz, Fagan & Miranda, 1975; Kasari, Freeman, Mundy & Sigman, 1995). Fixed eye gaze has been found to persist and remain as a primary response to speech until middle childhood in some children with the syndrome. Delays in transition from mutual eye regard to visual exploration and joint attention may reduce language learning opportunities.

While studies have identified developmental delays in establishing auditory and visual perception and discrimination skills, there have been no formal studies of the development of the receptive phonologies of infants with Down syndrome during the prespeech period. This may be partly explained by the reluctance of researchers to disrupt the developing parent child relationship. Delays in establishing knowledge of the phonemes, phonotactic rules and syntactic frames of the ambient language during the first year could contribute to difficulties in later speech development.

Imitation

Imitation skills are slower to develop in infants with Down syndrome and quantitative and qualitative variation from the typical developmental progression has been reported. Hypotonia, attentional and perceptual difficulties combined with delays in establishing motor control may delay the onset of imitation. Stronger stimuli are required to elicit reflex responses in neonates and delays have been reported in the appearance of synchronous movements, imitation of mouthing and facial expressions in the first month.

Transition to proactive movements occurs at a slower rate and delays in imitations of simple actions, facial expressions and vocalisations have been reported (Hooshyar, 1988; Rondal, 1980; Tager-Flusberg & Calkins, 1990). Children with the syndrome persist in direct imitation for a longer period than observed in typically developing children. This has been attributed to motor difficulties but could equally well reflect specific difficulties in the identification of movement goals. A reduction in goal focussed imitation will decrease learning opportunities as the child will not be encouraged to experiment and explore his or her motor capabilities to achieve goals. Persistence in direct imitation without adaptation to motor abilities will contribute to a higher error rate. Later imitation of routine action sequences appear to develop in an age appropriate manner but sequential difficulties may be present. Levels of imitation achieved by children with Down syndrome will depend on the degree of participation in social interactions and functioning levels in motor, sensory and general cognition.

The past decade has seen an expansion in knowledge of the neurological processes involved in imitation and new theories incorporating this knowledge are being developed and tested. These may allow for structured observation on the development of imitation skills in infants with Down syndrome. The information currently available derives mainly from studies of broad developmental patterns and comparisons with typically developing peers. Associated factors have not yet been identified. Table 2.1 outlines some possible factors which could constrain and alter the developmental path of imitation in children with Down syndrome.

Table 2.1 Constraints on imitation development in infants with Down syndrome

Perception of target may be reduced by
• Low activation thresholds
• Reduced habituation
• Sensory impairments: Auditory, visual, tactile, kinaesthetic
• Motivational status
Infant motor acts may be reduced in quantity or quality by
• Motor constraints
• Hypotonia
Equivalence detector may revive insufficient information due to
• Sensory integration difficulties
• Limited proprioceptive feedback

Developmental differences in goal directed imitation may result in atypical development in speech monitoring and crossmodal feedback systems and contribute to difficulties in short term processing and auditory memory.

Memory

Memory capacity increases rapidly during the first year in typically developing infants and by nine to ten months links between objects, places and events are well established and representational memory begins to develop. Infants with Down syndrome are slower to indicate stored knowledge of objects and events (Berger, 1990). Knowledge of routines and spatial location appears at an older age than in typically developing children. Delays in the representational use of objects are evident in symbolic play between twelve and eighteen months when comparisons are made with age matched peers.

Constraints on verbal processing and short-term memory emerge during childhood and studies have found discrepancies between short term verbal and verbal recall. Comparison between children and adults with the syndrome and control groups matched by mental age has shown that auditory recall as measured by short term memory tests falls increasingly below levels achieved in visual recall (Chapman, 1995; Jarrold & Baddeley, 2001; Kay-Raining Bird & Chapman 1994).

The majority of studies in the past decade have used the model of memory proposed by Baddeley (1990) to identify possible causes for these difficulties in short term recall. These have focussed primarily on the malfunctioning of the phonological loop but have failed to identify any specific deficits associated with the syndrome (Chapman & Hesketh, 2000; Jarrold & Baddeley, 2001).

Others have focussed on the role played by long term memory and the linguistic representational system in facilitating processing and short term recall. Environmental information is categorically linked to past experiences reducing demands on short term processing. This approach has been supported by recent research which found that increases in domain specific memory capacity accompany increases in domain knowledge in typically developing children. Models of memory which integrate short term processing and recall with long term memory and lexical knowledge associate difficulties in recall with restrictions on categorisation of information and / or disruptions of the processes linking new information with long term storage. These would indicate that the specific auditory memory deficit reported in children and adults with Down syndrome could reflect a reduction in their general linguistic knowledge base or specific restrictions on knowledge of the verbal items such as the digits frequently used to test this ability.

The role of neurotransmitters in information processing and recall is currently being explored with some studies indicating that imbalances may reduce both the efficacy and quality of recall. Preliminary findings of studies with children with Down syndrome have indicated differences in neurotransmitters and cortical activation patterns (Pinter et al., 2001). These may contribute to the difficulties in recall reported in this population.

Learning

Children with Down syndrome have been found to show qualitative differences in their approach to learning and to problem solving tasks when compared to typically developing age matched peers and with children with learning disabilities. Contingency learning has been identified as posing specific difficulties for infants and children with Down syndrome. Studies of infants at 9 months indicated a lack of contingency learning in the infants with the syndrome when compared to typically developing infants matched by chronological age (Ohr & Fagen, 1994). Ruskin, Mundy, Kasari, and Sigman (1994) found that at 24 months children with Down syndrome showed less interest in exploring objects to discover cause and effect relationships when compared to typically developing children matched by mental age.

Wishart (1993) explored learning patterns in infants and young children with Down syndrome in a series of studies, and found qualitative differences in learning approaches and learning styles when compared to control groups of typically developing and developmentally delayed children matched by mental age. These included reduced level of engagement in familiar tasks, delays in contingency learning and insecure knowledge of object concepts. She also identified periods of developmental instability with loss of previously mastered skills. Later studies indicated that the children with Down syndrome were using avoidance strategies frequently in response to simple problems solving tasks. The children were found to be adept at using opting out behaviours which enabled then to avoid the task or to persuade others to complete the tasks for them (Duffy & Wishart 1995; Wishart 1994). A review of studies by Wishart in 2001 indicated increasing support for the prevalence of a counterproductive learning style in children with the syndrome. The learning style was characterised by use of social behaviours such as eye gaze and smiling to avoid failure when faced with tasks at or slightly above current competency levels.

The avoidance behaviours identified by Wishart (1994, 1996, 2001) are similar to those used by children and adults in many communication situations. Fixed eye regard and smiling are used to obtain attention and assistance by infants. They are also considered appropriate for these functions in adult communication in many contexts. The persistent use of these behaviours in children with Down syndrome from an early age suggests that it would not be inappropriate to apply a similar description to the learning style as was applied by Shapiro to physical characteristics (1994: 86). The learning style would then be characterised by 'increased prevalence, precocious onset, greater severity, multiplicity and chronicity' of strategies to avoid failure while maintaining social interaction.

The cognitive constraints outlined in these sections may result in atypical foundations being laid for the development of language as a representational system. Language content develops from the knowledge of the world. This knowledge has to be abstracted, processed, classified and retained in memory by the infant during the early learning period. Delays or differences in cognitive development will reduce both the amount and type of learning and contribute to a language base that may be inadequate for formal verbal communication.

2.5 Social constraints

The perception of the physical, sensory and cognitive constraints associated with the syndrome by others in both the macro and micro environment will influence the language learning opportunities available to infants, children and adults with Down syndrome. Attitudes in the macro environment will determine the physical and social supports that will be available to the infant and to those in the micro environment to overcome early constraints. The socio political environment will influence the educational, vocational and social opportunities available to those with Down syndrome throughout their lives. Constraints in the macro

environment may restrict opportunities to avail of community facilities in health care, education and vocational training for many with the syndrome. Participation in work and in the social life of the community may also be restricted. Structured early education and integrated schooling has been found to have significant benefits for the development of communication skills in children with Down syndrome (Buckley, Emslie, Haslegrave, Le Prevost & Bird, 1993; Chapman, 1995; Connolly, Morgan, Russell & Fulliton, 1993) but may not be available to all. Integrated schooling while facilitating the development of cognitive, academic and communication skills may however place children at risk of developing atypical relationships with their peer groups. Negative attitudes to children with Down syndrome and to inclusion policies were evident in surveys of schoolchildren across four European countries (Gash, Guardia, Pires & Raul, 2000). Children from schools with inclusion were found to be less sociable towards children with Down syndrome than those from schools without inclusion. This tended to be more evident in older children (11 years) and could possibly be explained by difficulties in establishing and maintaining empathic friendships.

The social stigma of Down syndrome has decreased in western societies since the middle of the last century but children and adults with the syndrome and their families still have to face and overcome many prejudices. Surveys have indicated that many of the stereotypes associated with the syndrome are still prevalent in those working in educational and medical settings (Wishart & Johnston, 1990; Wishart & Manning, 1996). This may result in lower expectations, lower demands and restrictions on learning opportunities.

Those who differ from the majority in appearance or who are perceived as being less competent cognitively or linguistically are at risk of being treated as inferior, younger or more dependent members of the species and are thus denied equal status as communicators. Communication partners will often simplify their speech when talking to a speaker perceived as less competent. Any or all of the components of spoken language may be modified to achieve the short term goal

of effective interaction. The long term consequences of such strategies may be detrimental to language learning and the development of intelligible speech in children and adults with Down syndrome. Studies of developmental change in language over the past decade have indicated that learning the formal aspects of language is facilitated by the frequency of occurrence of sounds, words and syntactic frames in the ambient language. Simplifications of vocabulary will reduce input to the lexicon which acts both as a repository and an instigator of change for the phonological system. Simplifications of the grammar will reduce input to the phonological morphological and syntactic systems and will in addition deprive the learner of a scaffold to determine the meaning of new words available for inclusion in the lexicon.

Changes in interaction patterns may erode self confidence and contribute to patterns of learned helplessness and the use of social skills to avoid communicative responsibilities. Reduced demands for clarification may inhibit the development of repair strategies used by mature language speakers to increase intelligibility, clarify meanings and achieve effective communication in many different contexts. Social policies, public perceptions and attitudes to disability in general and to those with Down syndrome in particular will limit or expand participation in community life and consequently language learning opportunities.

The micro environment of infants with Down syndrome will vary greatly as the syndrome shows no class or culture bias. Infants with Down syndrome are born into families and environments that vary considerably across all dimensions (Mahoney, O'Sullivan, & Robinson, 1992). Families vary on many of the indices used to evaluate early language learning environments, including parental educational level, occupational status and parenting styles. They also vary in religious and social beliefs and attitude to disability.

The diagnosis of special needs at birth or in the immediate neo natal period results in a period of grief, anger and adjustment for many parents as they adapt

to changes in life plans and visions. Their attitude to the infant will be influenced by the attitudes of those present at the birth, their extended family and the communities in which they live. Personal values and belief systems will contribute to how an infant with Down syndrome is perceived and received by parents and significant others in the environment.

Infants with the syndrome have to overcome sensory and physical constraints when establishing relationships with those who share their environments. They may require longer processing, planning and response execution time than that allowed to typically developing children. They will therefore be slower to respond to the auditory and visual stimuli provided by caregivers and their responses may be weaker or similar to those seen in younger infants. Early non verbal interactions may not be as rewarding for parents who may have to move out of the intuitive caregiver mode and use conscious strategies to elicit and interpret responses.

Communication based on affective signals is slower to develop in infancy and shows differences through childhood. Smiling is delayed in onset and weaker in strength and duration (Berger, 1990). Cooing, laughter and affective state vocalisations also show a significant delay. Children with the syndrome may also experience difficulties in understanding and mimicking affect. Specific difficulties in interpreting facial expressions showing anger and fear were identified in studies by Wishart and Pitcairn (2000) in school age children with the syndrome. These difficulties were not found in children with a similar level of developmental delay or with typically developing children matched by mental age. Reduction in opportunities for successful affective communication may undermine the development of communication intent.

Eye contact and gaze patterns in infancy allow caregivers and infants to exchange simple messages. Infants with Down syndrome show delayed onset of eye contact, reduction in early face to face interactions, and differences in developmental progression. These changes to the typical developmental pathways

may make it difficult for the parent and child to establish joint reference and, consequently reduce opportunities to link speech with objects and events. Eye gaze patterns are used to serve the demanding, requesting, rejecting functions that will be later served by speech. Lack of experience of these communication frames may lower motivation and ease of acquisition of the verbal code. Children and adults with Down syndrome use eye gaze to withdraw from communication with others. Withdrawal of gaze or persistent fixed regard frequently occurs in response to clarification requests and may function to abdicate responsibility to others in verbal communication.

Social interaction and shared attention are necessary to provide the motivation and the skills to develop the language of the community. Infants with Down syndrome show reduced participation in joint activities and interactions with others when compared to typically developing groups (Berger 1990). Interactions are shorter, less focussed and consequently less rewarding for both participants. Differences in interaction patterns have been attributed to slowness in attending and responding to stimuli. A study by Hyche, Bakeman and Adamson (1992) indicated that the social signals given by infants with the syndrome at seven months were fewer, weaker and less intelligible to mothers than those used by typically developing children. This difference was not found with older infants but the combination of slow responses and weak signals could foster the development of a directive interactional style by parents and others in interacting with infants with the syndrome.

Studies of infant/carer interactions comparing infants with Down syndrome with their typically developing peers have found differences in the quality of interactions. Interaction patterns between parents and infants with communication impairment have been described as 'asymmetric and not always synchronous' (McTear & Conti Ramsden, 1992) with a significant reduction in communication opportunities (Mervis, 1990). The style is characterised by '... high levels of maternal stimulation and poorer reciprocity' (Berger, 1990:116). The high levels of stimulation may be of no benefit to the infant if attention focus is

not shared. The directive caregiver style may result from parents adapting their communication style in order to initiate and maintain communication with the infant but it may have negative consequences for the learning child. This style was found to limit vocabulary development in typically developing children (Harris, 1992) and is likely to have a similar effect on infants with Down syndrome who experience additional physical and cognitive constraints on joint attention.

Mismatches are frequently found between adult speech to children, adolescents and adults with Down syndrome across a range of contexts (Millar, 1987). Input in language form may be restricted and distorted with simplification of sentence and word structure and changes in word and sentence stress. The high number of imperatives and rhetorical questions and lack of response time may result in learned passivity and reduce motivation to communicate verbally. Later studies have reported similar findings across the life span and across a variety of communication contexts. Motivation to communicate may also be challenged by a reduction in listener responses to those with learning difficulties. A study by Beveridge and Hurrell in 1980 found that only 50% of initiations elicited any response in schools. Similar patterns in carer responses to the initiations of adults with learning difficulties have also been reported (van der Gaag & Dormandy, 1993).

Case studies and clinical reports would indicate an increased prevalence of social withdrawal behaviours in infants and young children with Down syndrome. Social withdrawal behaviours in typically developing infants are accepted signs or signals of organic and relationship disorders. Withdrawal has been associated with unstable attachment, anxiety, depression and pain. Withdrawal behaviours in infants with the syndrome may be passive or may include stimulatory behaviours to bring about endomorphin release such as spinning, rocking and hand flapping. These behaviours are again characterised by their 'greater severity, multiplicity and chronicity' (Shapiro, 1994:86) in this population. The increased prevalence of self stimulatory behaviours may be associated with a greater risk of autistic spectrum disorders. These have an estimated 5-7% incidence in children with Down

syndrome compared to .04% in the general population (Capone, 1999; Kent, Evans, Paul, & Sharp, 1999). The presence of withdrawal behaviours or autistic tendencies will reduce opportunities to learn from environmental experiences and may impose additional constraints on the development of the linguistic representational system.

The constraints encountered by infants, children and adults with Down syndrome in macro and micro social environments may restrict participation in the verbal interactions necessary to become a competent confident speaker. Directive communication styles, child passivity combined with difficulties in auditory processing and in speech production may all contribute to less talk, less speech and less of the everyday practice demanded by typically developing infants and children.

2.6 Summary Developmental constraints

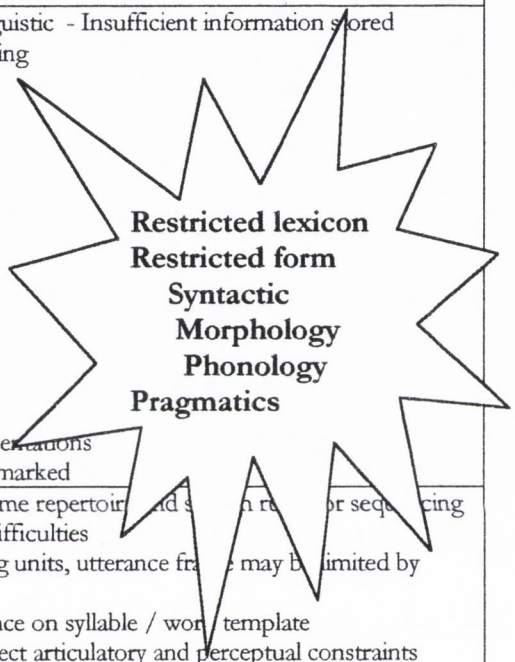
This chapter has outlined the constraints experienced by many infants, children and adults with Down syndrome as they try to develop speech as an effective communication channel. Others without the extra genetic material encounter similar constraints but 'their increased prevalence, precocious onset, greater severity, multiplicity and chronicity' (Shapiro, 1994: 86) may contribute to prolonged developmental period and atypical trajectories.

Table 2.2. relates these constraints to the framework for speech outlined in table 1.5.

Table 2.2. Constraints and influences on speech development

Input 1	Insufficient or inadequate environmental stimuli
Perceptual filter	Perceptual filter: Delayed habituation; Low activation thresholds;
Input 2	Auditory / Visual Impairment
Organiser	Motivational status Integration of multi sensorial information Difficulties in cross modal perception
Primer	Faulty priming to central processor Restricted knowledge of the world and / or of the linguistic system to represent it
Central processor	Limited experiences - life and linguistic - Insufficient information stored Dependence on inferential decoding Linguistic decoding restricted by limited knowledge of form Fuzzy representations Low communication intent Conceptual constraints Semantic response planner Non-linguistic output channel may be selected as more effective Response formulation slow Incorrect priming Generic categorisation contributing to Fuzzy word and phoneme representations Adoption and adaption of the unmarked
Response Formulator	Access to utterance frame, phoneme repertoir[illegible]d s[illegible]n r[illegible]or seq[illegible]cing may be restricted by processing difficulties Selection and ordering of meaning units, utterance fr[illegible] may b[illegible]imited by limited vocabulary and form Phonological planner - over reliance on syllable / wor[illegible] template Phoneme system modified to reflect articulatory and perceptual constraints Motor speech programme may reflect neurotransmitter deficits
Output	Timing / sequencing difficulties in assembly, transmission, actuation of motor plan Articulatory constraints on output
Feedback	Feedback loops to crossmodal referential system may not be developed Inadequate feedback from others to motivate monitoring Limited demands for repair

Restricted lexicon
Restricted form
Syntactic
Morphology
Phonology
Pragmatics



Many of these constraints have been associated with reduced motivation in infants and children with Down syndrome. Possible causes for differences in motivation may be found if constraints are evaluated and related to motivational drives. Maslow devised his hierarchy of motivational needs in 1954 to summarise the relationships between biological and social needs and their impact on individual growth and development (Figure 1.8).

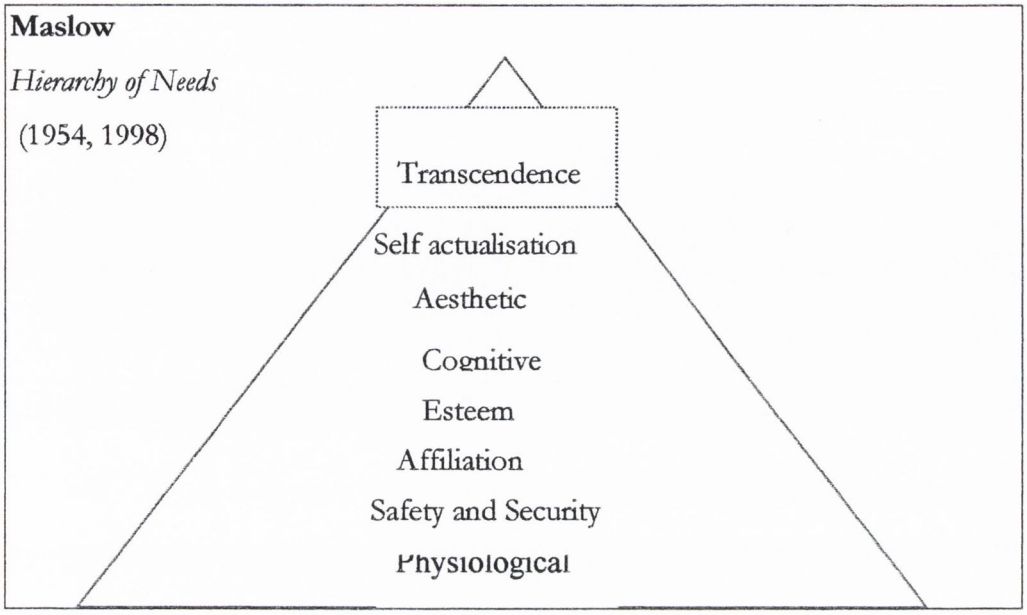


Figure 2.1. Hierarchy of needs adapted from Maslow & Lowery (1998).

Maslow proposed that the four basic needs - physiological, safety, affiliation, and esteem - have to be met in order to allow higher level human needs to emerge. Infants need to feel safe, secure, loved and recognised as competent before they can devote attention to exploring, abstracting and understanding the wider world of objects, actions and people. Unmet needs demand attention and influence motivational status and the ability to interact and learn from the environment. Needs related information seeking may result in limited attention to and rapid discarding of information unrelated to those needs. Information seeking styles were associated with specific needs by Norwood (1999). These have been adapted in table 2.3 and linked to some of the constraints experienced by infants, children and adults with Down syndrome as they seek to develop their potential.

Table 2.3 Need states, information seeking and constraints

Need	Information sought	Constraints experienced by infants with Down syndrome
Physiological	Coping	Illnesses; Feeding difficulties
Safety/security	Helping	Reductions in predictability Sensory and perceptual constraints Constraints on habituation and learning
Affiliation	Affirming	Social experiences Affect
Esteem	Empowering	Focus on failures Limited experiences of success
Cognitive	Enlightening	Constraints on learning opportunities

Unmet needs may reduce the energy available to pursue knowledge of the world to expand language content or to move beyond basic structures when developing language form. The needs, constraints and styles outlined in the table may explain findings of unproductive learning styles, loss of previously known information / skills and low motivation mastery reported from many studies of infants, children and adults with Down syndrome.

The development of speech, language and communication in children with Down syndrome shows variation from the profiles of typically developing infants and children. Variations have been reported in the pathways used, the pace followed and the progress achieved in developing the verbal communication systems of the ambient language. These variations will be explored in the next chapter. The current knowledge base on the development of speech, language and communication in children with and without the syndrome is not yet sufficiently robust to label developmental variations and impairments as delays, disorders or deficits. It may be time to move beyond this controversy and explore variation in verbal language in people with Down syndrome with the same frameworks that are applied to other populations in the diverse multicultural world of the twenty-first century.

CHAPTER 3

DOWN SYNDROME

SPEECH DEVELOPMENT, DELAYS AND DIFFERENCES

The constraints outlined in the previous chapter may result in children with Down syndrome being physically, cognitively, socially and linguistically disadvantaged at the point when they need verbal language to interact and learn from the environment. The development of verbal language, and of speech as a carrier of language poses specific difficulties for those with the syndrome. This chapter summarises approaches to speech development and impairment in children and adults with Down syndrome.

3.1 Developmental delays and differences

The constraints experienced by infants with Down syndrome will contribute to delays in developing the knowledge and skills that foster the development of language as a representational system, and of speech as a code for interpersonal communication. They have been found to show delays in achieving many of the milestones of language during infancy and childhood, and show differences in the content, form and use of verbal language at maturity. These delays and differences have been explored and explained by researchers who frequently hold

opposing views on the nature of the impairments associated with learning difficulties.

The extra genetic material may be seen as delaying development or as contributing to differences in developmental patterns. Those who adhere to the delay hypothesis hold that language is dependent on cognitive development and argue that the extra genetic material has a similar impact on both. The delay hypothesis is based on the assumption that children with Down syndrome acquire language and other skills in the same manner, but at a slower rate and with an earlier halt than typically developing children. Persisting communication difficulties are explained as the result of early language learning plateaux associated with constructs such as critical learning periods, limited cortical development and loss of neuronal plasticity. Psychometric tools are used to evaluate differences across domains in terms of mental age or developmental levels on the assumption that mental age is a valid predictor of linguistic achievements. Others would hold that the extra genetic material results in atypical developmental pathways. Atypical development is seen to contribute to differences and asynchronies within the developing and mature language code.

These approaches have been formalised in paradigms which have historically influenced research on many aspects of development and variation in speech and language. The majority of research findings up to the nineteen-eighties concluded that language development in children with Down syndrome showed a developmental lag commensurate with cognitive abilities. It was generally accepted that the delay profile was similar for comprehension and expression and that similar acquisition strategies to those seen in typically developing children were evident. Developmental differences, when identified, were viewed as symptoms of additional physical, medical or social conditions.

The broadening of the concepts involved in cognition and the availability of measures to assess the varied components of the verbal language system undermined the belief in delay as explanation. The identification of variations in

language learning in typically developing children resulted in further questioning of the appropriateness of the delay hypothesis. In addition, the delay concept was found to be inadequate by researchers working with older children and adults. Over the past two decades, researchers have presented data on developmental differences between infants and young children with Down syndrome and typically developing children in attention, social interaction, learning and language. Specific differences have been identified in linguistic development and asynchronies in language content, form and use are now recognised (Chapman, 1995).

Proponents of both delay and difference theories agree that the development and use of speech as a carrier of verbal language poses difficulties for many with Down syndrome. Developmental variations in rate, quantity and type which may impact on the developing speech system are summarised in the following sections.

3.2 Early language: development and delay

The majority of infants with Down syndrome will experience delays in reaching the milestones of early language transcended rapidly by typically developing children. Variations in developmental pathways which may influence the developing speech system are summarised in this section.

a. Get ready: Prelinguistic development

Typically developing children lay the foundations for language in the first year of life. This period of preparation for speech may extend to years for many infants with Down syndrome. Comparison with age matched typically developing infants indicates delays in the development of receptive language skills such as perception, discrimination and categorisation and understanding of first words (Berglund, Eriksson & Johansson, 2001; Eilers, Bull, Oller & Lewis, 1985; 1988; Miller, 1995). Expressive language skills and early communication patterns show

variation in the development of joint attention, imitation, turntaking and vocalisations when compared to typically developing infants (Berger & Cunningham, 1983; Sokotov, 1992). These variations are not seen when groups are matched by mental age leading many to conclude that cognitive and linguistic development follow similar pathways during this period.

Infants with Down syndrome are generally referred to as 'quiet babies' with sound making and babble reduced from the early stages. While this is generally accepted, research has been limited in this area because of the wide variation found in typically developing children. Affective vocalisations show a significant delay in infants with the syndrome (Berger & Cunningham, 1983). Findings from studies of pre speech vocalisations of infants with the syndrome are contradictory. Studies by Dodd (1972) and Smith and Oller (1981) found no variations in frequency, length and type of prespeech vocalisation. However, studies by Lynch & Eilers (1991) indicated that canonical babble was approximately two months delayed in onset when infants with the syndrome were compared to typically developing infants and later studies indicated differences in the ratio of canonical syllables in utterance (Steffens, Kimsbourgh, Oller, Lynch & Urbano, 1992). Variations in the types of early sounds was also found in the studies of Smith & Oller (1981) with increased lingua labial and bilabial trills evident in infants with Down syndrome. The delay in canonical babble and presence of atypical sounds may contribute to variations found in maternal responses to babble. A study by Velleman, Mangipudi & Locke, (1989) indicated that maternal responses to the early sound making of infants with Down syndrome contained fewer phonetically contingent responses. This may be attributed to lack of clarity in the child production or may reflect parental perception of the child role as communicator but regardless of cause will result in the infants receiving less information on the features of the phonological system

Variations in the quantity of early sounds has not been researched but it is possible that differences in the amount of babble would account for parental perception of quiet babies. The babble patterns of late infancy may facilitate the

development of motor patterns that serve as templates for early words (Kamhi, 1992 b; Strand, 1992). Stoel-Gammon (1998) suggests that amount of babble in infancy may determine ease of articulation in early words. Developmental variations in the preverbal period are summarised on table 3.1. These have been divided into variation in time, quantity and type with the categories defined as follows:

Time: Delays in onset or cessation of preverbal and verbal milestones
Quantity: Decreases or increases in communication behaviours.
Type: Variations in the communication form or function

Table 3.1. Summary of variations: Prelinguistic

Preverbal	Time	Quantity	Type
Categorical perception	?	?	?
Joint attention	+	+	+
Language specific babble	+	?	+
Imitation	+	?	?

Similar = Reported variations + Suggested variation ?

Developmental delays and variations may result in linguistic constraints on infants with Down syndrome as they pass into the early language stage.

b. Steady: early speech and language

Children with Down syndrome are slow to start to use speech to communicate and their progress through the early speech period shows variations from the typical pathways in quantity and type of communication. The reported delay in first words in relation to chronological age varies from months to years (Berglund et al., 2001; Rondal, 1988; Miller, 1995). Studies examining first words relative to mental age have reported less variability with words emerging at similar mental ages for infants with and without the syndrome (Beeghly & Cicchetti, 1990; Gillham, 1990; Miller, 1992). Comparisons with mental age matched peers indicate that children with the syndrome are slower to acquire new words and accumulate vocabulary (1990; Fowler, 1990). Prolonged use of signs and babble support early communication (Hopmann & Nothnagle, 1994; Smith & Stoel

Gammon, 1983). The vocabulary spurt seen in typically developing children at a mental age of approximately 18 months may not occur in children with the syndrome until a base of 23 months is achieved (Mervis, 1990; Miller, 1992). This variation appears to be linked to quantity as categories and token types remain close to mental age expectations (Mervis, 1990).

Children with Down syndrome and typically developing infants both show a rapid increase in the use of gestures to accompany early words. These fade in typically developing children as spoken vocabulary expands whereas infants and young children with Down syndrome frequently show prolonged dependence on concrete, primitive and relational signs to serve communication needs during the early language development period. Infants with Down syndrome have been found to be quicker to master sign vocabulary than speech and findings suggest that vocabulary growth in signs appears to be in keeping with cognitive development (Miller, Sedley, Muelo, Rosin & Murray -Branch, 1991).

Early word combinations begin to emerge when the expressive vocabulary reaches a stable level between 50 and 100 words in typically developing children but those with Down syndrome may continue to depend on single words or combined words and signs until they are using 300 plus single words consistently (Fenson et al., 1994). The transition to word combinations may be delayed due to restrictions on the phonological system.

Differences in phonetic inventories used by infants with the syndrome compared to their peers have been reported during this period. Studies indicate that the use of central vowels increases in infants with Down syndrome while the opposite occurred in the matched group. Differences in consonant repertoires exist with infants with the syndrome showing a delay in developing oral nasal contrasts and restrictions on place of articulation. Syllable structures may also be slower to develop with reduplication and open syllables are more evident than in typically developing children. Variations from the typical pathways in the early speech period are summarised in the table 3.2.

Table 3.2. Summary of variations: Early language

Variations in	Time	Quantity	Type
Imitation	+	=	+
Language content	+	+	=
Language form	+	+	+
Language use	+	=	+

Similar = Reported variations + Suggested variation ?

Protracted development may contribute to differences in developmental trajectories and to asynchronies in language content, form and use at the onset of formal language development. Impairment is evident in the verbal code from the early speech period and expressive difficulties become increasingly evident as receptive language skills develop and communication needs and demands increase (Chapman, Seung, Schwartz & Kay Raining Bird, 1998). The developmental asynchrony may bring with it increasing impairment, disability and handicap.

At the end of the early language development period the majority of children with Down syndrome will present with restricted knowledge of the world and of the linguistic system to represent this knowledge. Their communication needs will be similar to their peers and they may need to modify and adapt the formal language system in order to interact productively with their communities.

c. Go: Formal language development

Language encodes individual world knowledge, and language content in general, and the lexicon in particular, will reflect life experience and learning opportunities. The vocabulary levels attained by children with Down syndrome will mirror their experience and past learning. Studies indicate that both receptive and expressive vocabulary acquisition proceeds at a slower rate than in typically developing children (Barret & Diniz, 1989: Miller, 1995; Rondal, 1988; 1996). Expressive vocabulary is slower to develop than receptive and remains well below levels attained by typically developing children matched for chronological or mental ages in the first five years of life (Buckley, 2000; Chapman, 1997). Delays are

evident in the linking of vocabulary to the formal language system with productive vocabularies of 300 words necessary to trigger grammatical word combinations.

Children with Down syndrome show delay in developing the formal components of the linguistic system. Protolanguage is retained for a longer period. Creative word combinations are slower to appear and syntactic development shows protracted plateaux, which are not seen in typical development (Fowler, 1990). Morphological structures seldom appear during the early language learning period. Delays are evident in both receptive and expressive language but studies indicate that variations in form are more evident in expressive phonology, morphology and syntax (Chapman, Seung, Schwartz & Kay Raining Bird, 1991, 1998; Fowler 1990; Miller, 1995; Parsons & Iacono, 1992).

Phonological development during early language development follows the stages observed in typically developing children but at a slower pace and with 'more errors, processes or multiple processes co-occurring than is found in other populations' (Parsons & Iacono, 1992:44).

Table 3.3. Summary of variations: Formal language

Formal language	Time	Quantity	Type
Language content	+	+	=
Language form - syntax	+	+	+
Language form-morphology	+	+	+
Language form- phonology	+	+	+
Language use	+	+	+

Similar = Reported variations + Suggested variation ?

Children with Down syndrome show variation in all aspects of language as they move from the early language learning period.

3.3 Language steady state

By the age of four typically developing children are able to use language to serve the pragmatic demands of the present, to recall the past and speculate on the future in conversations with members of the community. Language content, form

and use achieve a steady state of harmony during mid to late childhood. This state allows the child to fully exploit the representational linguistic system to interact with others in their communities. Developments in content, form and use continue to expand the language system throughout life but major asynchronies do not typically occur.

The majority of children with Down syndrome show disassociation between language content, form and use when they enter into the steady language state and many of these will persist throughout the lifespan. Studies of speech and language in older children and adults indicate that asynchronies and constraints may result in modifications to the components of the language system and the adoption of an atypical spoken language system to achieve and maintain functional communication in society.

Miller and associates identified three profiles of language development in children with the syndrome (Miller, 1995; Miller, Leddy, Miolo, & Sedey, 1995). Profiles of the majority (64%) indicated that the development of expressive skills failed to match receptive language development and non-verbal mental age measures. An even pattern of development across receptive and expressive language, with both reflecting non verbal mental age measures was found in 34% of the children studied. The third profile showed expressive language lagging behind receptive and receptive behind non-verbal mental age in 2% of the group. Longitudinal data indicated an increasing discrepancy in expressive skills relative to levels indicated by receptive measures. An increasing discrepancy between language and non verbal cognitive skills over time has been noted in a number of studies (Buckley, 2000; Chapman, 1997; Chapman, Crais, Salmon, Strand & Negri, 1992; Chapman, Ross & Seung, 1994; Chapman, Schwartz, & Kay-Raining Bird, 1991). The identification of subgroups, and the recognition of specific difficulties in language form emerging over time, has contributed to a shift away from global delay as a causal explanation for variation in communication skills.

Language content

Vocabulary development shows slow steady increases throughout childhood in children with Down syndrome with vocabulary levels reflecting general levels of cognitive ability in quantity, type and semantic relationships. Their ability to learn new words is similar to that of cognitively matched peers. (Chapman, 1995; Chapman, Kay -Raining Bird & Schwartz, 1991). Clinical experience and parental reports indicate that vocabulary continues to develop and expand with life experiences in adolescents and adults with Down syndrome. This development is not measured by many of the tools currently available to establish vocabulary levels but evidence for continued growth and development was indicated by a long term study by Berry, Groenweg, Gibson, & Brown, (1984).

Language form

Children with Down syndrome enter the period of language expansion with constraints on the development of language form. Typically developing children are intelligible by the age of four years and can use speech effectively to communicate with unfamiliar listeners in many contexts. Surveys of parental opinions of speech intelligibility in children and adults with Down syndrome indicate that only 30-40% will achieve this level of intelligibility (Pueschel & Hopman, 1993). A survey by Kumin (1994) indicated that 60 % of children and adults with the syndrome in the age range 4-40 years had difficulty being understood outside the home. The low speech intelligibility levels attained have been associated with impairments of the phonological system

Phonology

Patterns of phonological development in children with Down have been found to be similar to those shown by typically developing children. Phoneme inventories show similar acquisition patterns and similar processes are present (Dodd & Leahy, 1989; Parsons & Iacono, 1992; Stoel–Gammon, 1980; Van Borsel, 1996). The developmental process, which is virtually completed in typically developing children over a two year period, is protracted in those with Down syndrome and early patterns may persist into maturity (Hamilton, 1993; Rondal, 1996).

Syntax and Morphology

Children with Down syndrome show delays in the development of syntax and morphology (Fowler, 1995; Miller, Leddy, Miolo & Sedey, 1995) and these aspects of language form remain below the levels expected for nonverbal cognitive ability throughout the lifespan (Abbeduto, Pavetto, Kesin, Weissman, Karadottir, O Brien & Cawthon, 2001; Rondal 1995). These delays are found in both receptive and expressive aspects but with the expressive showing greater impairment at all levels. This asynchrony persists through to the adult years (Chapman, 1997; Rondal & Comblain, 1996).

Comparisons between children and adults with Down syndrome and other groups by cognitive levels indicate that mean length of utterance is consistently shorter in both adults and children with the syndrome (Chapman, Seung, Schwartz, & Kay-Raining Bird, 1998; Fowler, Gelman, & Gleitman, 1994; Rondal, 1996). Comparison of sentence structures using mean length of utterance indicates that sentences show reduced clausal complexity and omission of function words and morphological inflections.

Language use

Children with Down syndrome who have developed verbal language proceed to use it to serve the same range of functions as their typically developing peers

when matched for language level. They can exchange intended meaning with others in spite of the restrictions many experience on language content and form (Rondal, 1995; Van der Gaag & Dormandy, 1993). Adolescents and adults with the syndrome show language age related comprehension and use of a wide range of speech acts, narrative and conversational skills (Rondal & Complain, 1996). Their conversational and narrative skills may in many instances be above the levels shown by language age matched peers in structure and content due to their additional life experiences (Fowler, 1995).

The protracted learning period and developmental asynchronies outlined in this section may contribute to the higher incidence and prevalence of communication impairments in children and adults with Down syndrome than is found in either the general population or in other groups with learning disabilities (Buckley et al., 1993; Miller, 1995; Rondal, 1995).

3.4 Communication impairments

The dominance of the delay paradigm in approaches to Down syndrome resulted in research which focussed on general language and communication skills with mental age based comparisons used to determine the presence and severity of impairments. The accepted view of the communication patterns of those with Down syndrome as 'delayed without deviance' resulted in limited research to identify specific impairments. Evidence of developmental differences found in studies was accommodated in the delay framework and patterns were described as 'delayed with deficits' (Fowler, 1990; Miller, 1995) rather than reclassified as a specific impairment. There is increasing recognition that many of the deficits identified are similar in type to communication impairments in the general population. Impairments of language, voice and fluency show a greater prevalence in children and adults with Down syndrome than is found in either the general

population or in other groups with learning disabilities (Rondal, 1987, 1995; Miller, 1988). Impairments in any aspect of verbal language, fluency or voice will impact on speech as a channel for interpersonal communication.

3.5 Phonological impairment

Children and adults with Down syndrome may be deemed ineligible for inclusion in the clinical grouping of those with phonological impairments due to the exclusionary clause in the Diagnostic and Statistic Manual of Mental Disorders (2002)

> 'If mental retardation, a speech-motor, or sensory deficit, or environmental deprivation is present, the speech difficulties are in excess of those usually associated with these problems' (DSM-IV: 2002: 315:39)

The lack of knowledge on patterns of association between phonological impairments, learning difficulties in general and the specific impairments of those with Down syndrome coupled with constraints on service provision has contributed to reduced focus on speech in therapy programmes over the past decade. Phonological impairments have been perceived by many as intractable and therapy has focussed on developing areas of strength.

Studies of phonological impairment in children and adults with Down syndrome indicate that they share many linguistic features with typically developing children who present with similar impairments (Bass & Swanson 1997; Dodd, 1976; 1995; Parsons & Iacono, 1992; Van Borsel, 1996). They show

i). Variations from the phonemic inventory of the target language in

- Quantity: Reductions in phoneme number
- Type: Use of a phonemic inventory atypical of the language
- Quality: Differences in phonetic realisations of phonemes

ii). Variations from the rules of the phonological system of the target language

- Quantity: Mismatch between number and strength of rules / processes / rankings required
- Type: Application of inappropriate rules, processes, or rankings
- Quality: Inconsistent or variable rule / process application

Quantitative and qualitative differences have been identified by some studies in aspects of the phonological system in children and adults with Down syndrome. These include differences in phonetic realizations, inconsistency in productions and an increase in the number and strength of phonological processes.

Phonetic and phonemic inventories

Findings from studies, which examined phonetic detail, indicate differences in feature realisations. Parsons and Iacono (1992) identified allophonic type errors in 40-60% of participants with Down syndrome. A comparative study of error types in adolescents and adults with Down syndrome and typically developing children found a greater percentage of ambiguous productions, voicing errors and deaffriaction in those with the syndrome (Van Borsel, 1996). Changes in vowel patterns have also been identified and a tendency to centralise vowels for a longer period noted (Berglund, Eriksson & Johansson, 2001). These findings coupled with results from electropalatographic studies (Hamilton, 1993) could indicate oral motor or motor planning difficulties in addition to phonological impairment in children and adults with Down syndrome.

Inconsistency

Typically developing children show restricted and consistent variability in phoneme use during periods of phonological change. Studies indicate that this pattern is amplified in children with Down syndrome and greater variability and inconsistency has been reported in both developing and static systems in this population (Dodd, 1976; Dodd & Leahy, 1989; Stoel-Gammon, 1981). Inconsistency has been associated with difficulties in motor planning (Dodd, 1995).

Variations from the rules of the phonological system

Studies using process analysis have identified a greater number of active processes in the speech of children with Down syndrome (Dodd, 1976; Dodd & Leahy, 1989; Parsons & Iacono, 1992). The number and strength of processes has been found to be greater in those with the syndrome compared to language matched peers. The co-occurrence of multiple processes was identified as specific to the group with Down syndrome.

Process limitation and suppression occurred at a slower rate in children with Down syndrome studied over a three year period by Smith and Stoel-Gammon (1983). The typically developing children in the age range 18-36 months showed a suppression rate of 38% over a one year period. The children with Down syndrome took three years to achieve a suppression rate of 21%. There is some evidence that children with the syndrome vary from the usual pattern in the order of process suppression (Sommers, Patterson & Wildgen, 1988). Studies of older children and adults indicate that many processes remain unsuppressed into maturity. Table 3.4. compares the processes reported as occurring in the speech of children and adults with Down syndrome to those reported in typically developing and phonologically impaired children.

Table 3.4. Phonological processes in development and impairment

Process	Typical	Phonological Impairment	Down syndrome
Final consonant deletion	√		√
Initial consonant deletion		√	√
Unstressed / Weak syllable deletion	√		√
Cluster reduction	√		√
Cluster deletion		√	√
Fronting	√		√
Backing		√	√
Glottal replacement		√	√
Systemic Sound preference		√	√
Stopping	√		√
Voicing /Devoicing	√		√
Affrication		√	√
De-affrication	√		√
Gliding	√		√

The phonetic and phonological features identified in the phonological systems of children and adults with Down syndrome who present with phonological impairments indicate influences from both linguistic and motor systems.

Many of the sensory, motor, cognitive and social constraints outlined in the previous chapter have been associated with phonological impairments in the general population and their increased prevalence in those with Down syndrome may contribute to the increased prevalence of phonological impairments in this population.

3.6 Summary

Communication impairments in children and adults with Down syndrome show 'increased prevalence, precocious onset, greater severity, multiplicity and chronicity' (Shapiro, 1994:86). The model of 'amplified developmental instability' developed by Shapiro (1975, 1989, 1994) to account for this variability was based in a neurogenetic evolutionary framework but could equally well be applied in

frameworks based in transactional theories and systems change. The extra chromosomal material may be viewed as influencing

- the evolved genetic developmental pathways with a greater effect on traits that are the least developmentally stable in the normal population.

- the developmental relationships between infants, caregivers and community as they cope with the physical, sensory and cognitive constraints associated with the syndrome.

- the organisation of alternative functional systems based on adaptations imposed by developmental constraints and the need to interact productively with the community.

Any or all of these explanations could be equally valid and further research is required in many areas to explore the concepts of developmental delays, differences and impairments. Differentiation of delays, impairments and disabilities has been influenced by medical, social and economic paradigms and many of the underlying concepts remain nebulous. This review of the knowledge base on speech delay and impairments in children and adults with Down syndrome while indicating greater delays in speech development and a higher prevalence of speech impairments, has not provided support for any one key model or approach to classification or causation.

Introduction to the studies

Many children, adolescents and adults with Down syndrome are good communicators but poor speakers. They experience restrictions in both learning and using speech as an efficient and effective tool for interpersonal communication. The literature review identified some of physical, cognitive, social and linguistic constraints on speech development encountered by many children and adults with Down syndrome. These constraints contribute to an increased prevalence and greater severity of impairments of all components of the verbal language system.

These studies focused on low speech intelligibility and phonological impairment identified from clinical experience and the literature review as imposing additional constraints on the social, educational and vocational development of children with Down syndrome. Low speech intelligibility has been found to be present from the early stages of speech development and to persist throughout the life span for many with Down syndrome.

Studies of speech intelligibility and phonological impairments in children and adults with Down syndrome indicate that they share many linguistic features with typically developing children (Bass & Swanson 1997; Dodd, 1976; 1995; Parsons & Iacono, 1992; Van Borsel, 1996). Therapy outcomes have generally been found to be less satisfactory that those achieved in the same time frame with typically developing children.

These studies were designed to

- Identify the characteristics of the phonological systems of a group of children and young adults with Down syndrome

- Compare the characteristics found in the Down syndrome participant group to those found in a group of typically developing language age matched children

- Determine if specific clinical markers or characteristics of speech impairment could be identified for this population.

- Identify factors in the formal components of language associated with restricted phonological systems

- Identify of patterns of change and development in the phonological systems of the individuals with Down syndrome

CHAPTER 4

METHODOLOGY

4.1 Introduction

The proposal that children and adults with Down syndrome experience constraints in achieving and maintaining intelligible speech is supported by past research and clinical experience. A review of the literature indicated that while the prevalence of speech impairment in children with the syndrome has been extensively recorded, and many features have been described in detail, the characteristics of the presenting speech patterns have received less attention. These studies were designed to explore the nature of low speech intelligibility and the characteristics of phonological systems in children and young adults with Down syndrome in order to:

- Determine if specific clinical markers or characteristics of speech impairment could be identified for this population.
- Identify similarities and differences between patterns present in the group and those found in children developing language within the usual time frame.
- Identify factors in the formal components of language associated with restricted phonological systems
- Identify patterns of change and development in the phonological systems of the individuals with Down syndrome

Data for the studies were collected from participants in two projects undertaken over a three-year period. The children and young adults with Down syndrome were participants in a project seeking to identify influences on speech

intelligibility, and to devise, implement and evaluate the efficacy of therapy programmes with this population (summarised in Appendix 4.1).

Data for typically developing children came from the participants in screening projects undertaken in inner city preschools and primary schools in association with community based speech and language therapists. These screening projects were undertaken in order to identify children at risk of educational difficulties due to speech and/or language impairments. Data obtained from these screenings were used primarily for local speech and language therapy service planning, but also provided a data bank on language and phonological development.

Study 1 explored patterns of speech development in children and adolescents with Down syndrome. Data from this group were matched by language age with data from a group of children developing language within the typical time frame. The data were analysed initially to compare the groups across the language age range 24 – 84 months. Developmental patterns in the data were then explored at three language levels.

Study 2 used a correlational design to explore data gathered during pre therapy assessment sessions in a clinical setting from a group of 40 participants from the Study 1 Down syndrome group. Data from receptive and expressive language measures were used to seek out relationships between restricted phonological systems and developmental levels in vocabulary, morphology and syntax.

Study 3 used a quasi-experimental design to examine patterns of change and development in the phonological systems of the group from Study 2 over a thirty month period. The group was split into two sub groups. Measurements were obtained from both groups at time one. Participants in Group A were assessed and waitlisted for therapy with no direct intervention for 12 months. Group B commenced therapy within two months and attended for 20 sessions over a seven to eight month period. Measurements were then repeated for both groups. Group A then commenced therapy and attended for 20 sessions over a seven

month period. A final set of measurements was obtained from this group within two months of completing therapy.

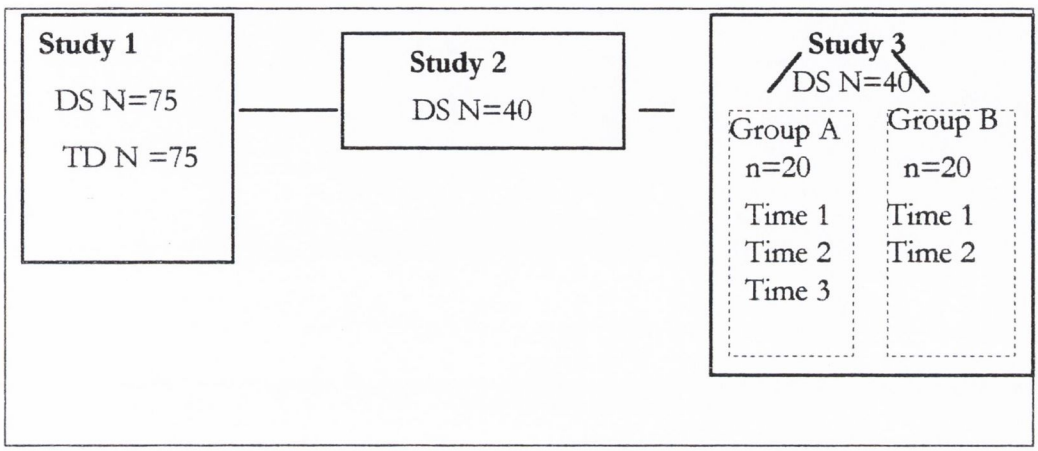


Figure 4.1: Outline of the Studies.

This chapter describes the methodology of the studies in five sections as follows: -

Research questions

Description of variables

Participant selection

Description of tasks and measures

Data collection and analysis

4.2 Research questions

Research on speech intelligibility has identified many variables that contribute to effective verbal communication. The questions asked in this study were confined to variables rooted in the spoken language system of speakers as perceived by listeners. This therefore excluded the motoric aspects of message transmission along with variables associated with speaker / listener interaction and

communication contexts. This focus was supported by past research, which indicated that children with Down syndrome encounter more difficulties in developing expressive verbal language than with receptive or pragmatic skills. Their developmental pathways can vary from those of typically developing children in both time and manner.

These variations have been explored in the past primarily in research deriving from two opposing theoretical stances. Those who hold that the patterns associated with the syndrome represent delay and arrest in language development due to cognitive / neurological constraints have focussed on the identification of features typical of early language. Others who have sought to identify patterns unique to the syndrome have focussed on deviancy. The research questions posed in the present set of studies approached variation in a manner that could accommodate both stances. The research questions sought to identify why children and young adults with Down syndrome who were good communicators experienced difficulties in achieving intelligible speech.

Study 1: Research questions:

1 Does speech intelligibility reflect competency levels in general language skills?

2 Do speech intelligibility levels reflect levels of phonological system development?

3 Do the phonological systems of children and young adults with Down syndrome reflect developmental patterns of typically developing children?

4 Are there specific characteristics or clinical markers of speech impairment associated with Down syndrome?

Studies 2 and 3 asked questions on possible relationships between speech intelligibility, limitations in the phonological system and developmental levels in

vocabulary, morphology and syntax as components of language form. These were:

5 Is speech intelligibility level associated with levels of development in general language, or in receptive or expressive, vocabulary, morphology or syntax?

6 Are restrictions in the phonological system as measured by consonants correct, process analysis or system rating associated with developmental levels in receptive or expressive vocabulary, morphology or syntax?

7 Is accelerated change in intelligibility reflected in changes in the phonological system?

8 Are periods of change in phonological systems associated with changes in other components of language?

9 Are there similarities between patterns of change in the phonological systems of individuals with Down syndrome and those encountered in languages during periods of acquisition and change?

The key concepts in the above questions are

Intelligibility

General language ability

Vocabulary

Phonological system

Morphology

Syntax

4.3. Description of variables

These concepts are defined in many ways by the disciplines involved in the study of verbal language and communication. Restrictions on generic meanings were required in order to operationally define these concepts as variables for these studies. Operational definitions were used to select and devise tools and procedures, which would allow valid sampling, measurement and analysis of relevant data.

4.3.i. Intelligibility in interpersonal communication is influenced by many social, linguistic and pragmatic factors (outlined in chapter 1) but for the purpose of these studies speech intelligibility was defined as clarity of speech as judged and rated by family members and experienced speech and language therapists from conversational speech samples. The rating scale is presented in section 4.5.i and 4.6.i.

4.3.ii. The development of intelligible speech is linked to the acquisition of a general knowledge and skills base in the target language. The studies used the term **General language** to refer to broad developmental levels of receptive, expressive and pragmatic verbal language skills shown by typically developing children in the period between 2 and 8 years, the period of maximum increases in speech intelligibility. The Preschool Language Scale–Revised (Zimmermann, Steiner & Evatt-Pond, 1979) a broad based assessment of language content, form and use was used to measure this ability. The generic nature of this assessment did not however allow for the measurement of specific aspects of vocabulary, morphology and syntax linked to speech intelligibility and phonological development in the literature.

4.3.iii. The term **Vocabulary** was used in these studies to refer to estimates of the number of words understood and used by participants. These estimates were obtained by the use of the British Picture Vocabulary Scale (Dunn, Dunn, Wharton & Pintille, 1982) and the Renfrew Action Picture Test (Renfrew, 1989). Both measures are in general clinical use but scoring was adapted to allow

developmental levels to be assigned in studies 2 and 3. These tests and the scoring procedures are discussed in 4.5.iii. The development of the understanding and use of lexical items has been linked with changes in the phonological system

4.3.iv. The development of a **Phonological system** consistent with the ambient language is a basic requisite in achieving intelligible speech. This system was operationally defined as the inventory of phonemes and the rules operating to organise these sounds to signal meaning in the language for the purpose of these studies. The measures selected were those in common clinical use to describe and analyse developing phonological systems, and to compare these with target language systems. Comparison of the phoneme inventory and the organisational rules of individual phonological systems allows the key features of phonological development and impairment to be identified.

4.3.v. The key features of the **Morphological system** associated with intelligibility and of interest in studies 2 and 3 were function words and inflections. The understanding and use of function words and inflections were sampled by the use of sections of the Test of Auditory Comprehension of Language (Carrow-Woolfolk, 1985) and the Renfrew Action Picture Test (Renfrew, 1989) with scoring again modified to capture broad developmental levels. The broad concept of **Syntax** was restricted in the study to the identification of early developmental levels of phrase, clause and sentence forms from structured speech samples.

Measurements, sampling and scoring procedures for the above variables using are described in detail in sections 4.5. and 4.6.

4.4 Participants

Participants for the studies were selected from those involved in two clinical research projects.

Down syndrome group pool

Those with Down syndrome were attending the clinic to participate in therapy programmes to explore therapy efficacy. Participants for the therapy project had been selected from parental responses to a circular outlining the project and questionnaires distributed by the local Down Syndrome Association. Completion of the application form and questionnaire was taken as consent for data collection at this stage of the project. One hundred and twenty potential participants were screened by analysis of parental rating scales (Communication Skills Rating Scale; appendix 4.2) and by a speech and language screening assessment battery using informal assessments and speech samples to evaluate language levels, intelligibility, fluency and voice. Forty five of the potential participants were ruled out as low intelligibility was found to be associated with language levels below the 24 month base (18%) or associated with disorders of fluency (2.6%), voice or resonance (3.5%). Two participants were ruled out as they presented with severe hearing impairment.

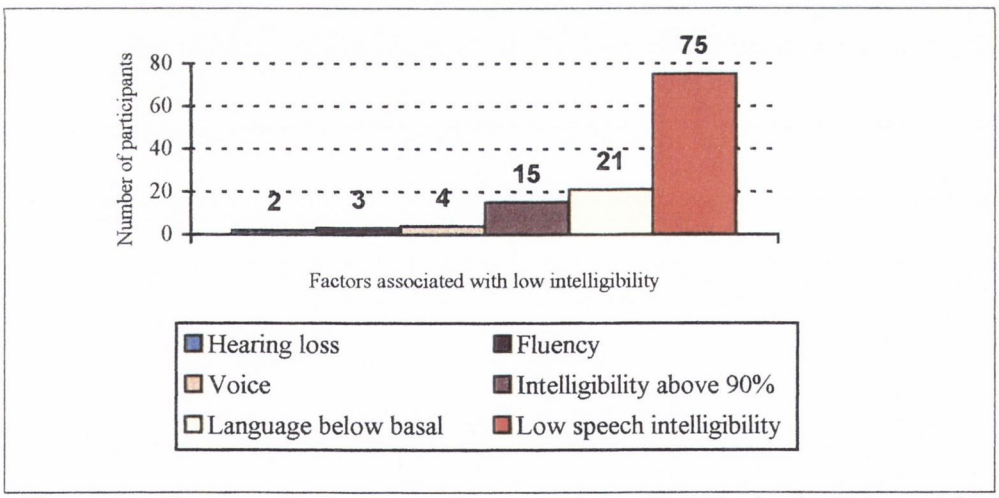


Figure 4.2: Factors contributing to low speech intelligibility in the DS participant pool

The 75 children and young adults from this group who presented with low speech intelligibility above the base language age were selected for study one.

Participants selected

The carers of the seventy-five participants selected from the group with Down syndrome were invited and agreed to attend with participants for a one-hour assessment for the initial study. The project was outlined to parents and participants during the assessment session and consent for assessment/ therapy was obtained (appendix 4.2). There were 50 males and 25 females in the participant group ranging in age from 4.2 to 27.5 years (50 – 288 months; Mean 128.8; SD 63). The majority of the participants were in the younger age groups as the indicated by the figure 4.3.

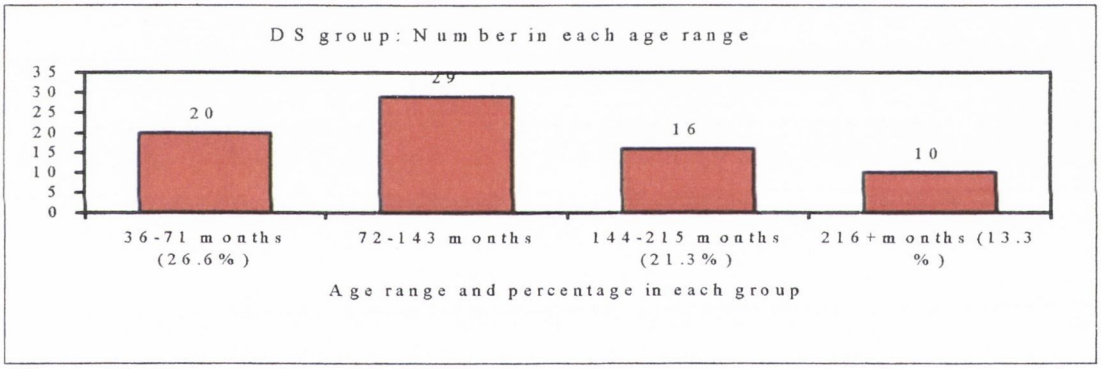


Figure 4.3: Down syndrome participant group: Age range

Characteristics

Medical

Case histories indicated that all of the participants had a clinical diagnosis of Down syndrome (Trisomy 21) with no reported cases of translocation or mosaicism. Medical histories did not reveal the presence of any severe cardiac or neurological conditions but indicated sensory impairments in half of the participants. Visual impairments were reported in 26% (corrected by glasses) and hearing impairments due to recurrent respiratory tract infections in 51%. The majority of those with positive histories of ear infections had grommets inserted on at least two occasions and were not presenting with hearing loss at the start of the study.

Family composition

The majority of the participants (72: 96%) were living with both parents. Three were living with their widowed mothers. The number of siblings ranged from 0–8 (mean 3.2). The majority of participants (62%) were the youngest in their families at the time of the study, 20% were second youngest and 11% were the eldest.

Socio-economic grouping

Occupational grouping was classified using the Data Analysis for Speech and Language Therapy (E.H.B. 1996: Summary appendix 4.3:). This classification was adapted from the International Standard Classification of Occupations (I.S.C.O.-88, 1991). The I.S.C.O. classification is based on tasks, duties and skill levels, which constitute an occupation. Analysis of parent questionnaires indicated that occupational classes ranged from professional to production and assembly workers with the majority falling into the mid range as indicated on the graph below. Ten responses could not be classified due to lack of information.

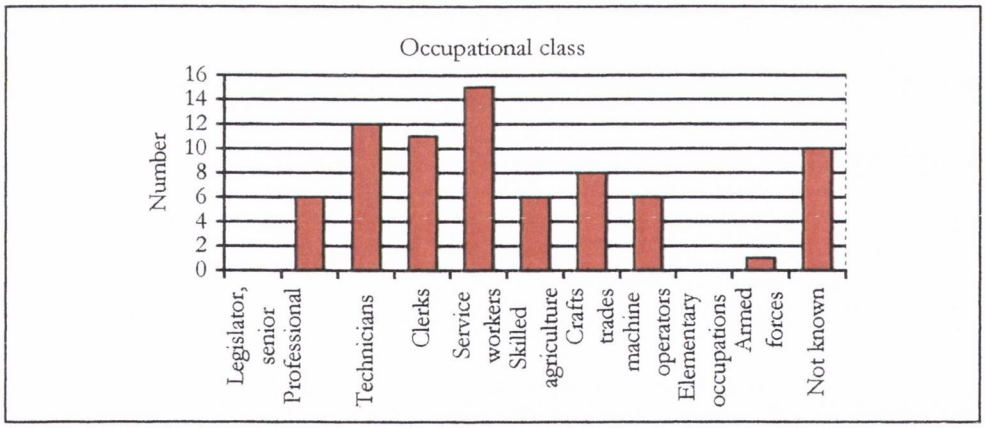


Figure 4.4: Occupational grouping in participant families

Developmental levels

All participants presented with a history of developmental delay in early social, motor, and language milestones. Case histories indicated that all were experiencing mild to moderate impairment in social, cognitive and educational

functioning at the start of the study. Psychological assessments were not available for the majority of the participants (69:92%) due to the limited local psychological services.

Educational placements

The majority of participants were attending educational services for children with mild to moderate intellectual impairment. Approximately one third were participating in projects to integrate children with Down syndrome in their local primary schools. At the upper age, two of the adults were in part time employment

Table 4.1 Participant educational and occupational placements.

Pre-school (special)	13%
Pre-school	12 %
National School (special*)	43%
Primary School	20%
Training centre	9%
Work	3%

* National schools designated as special provide both primary and secondary education pupils with special needs in the age range 4 -18 years

Previous speech and language therapy

While all participants were presenting with impaired communication skills none were attending for speech and language therapy at the time of the study due to service shortages. Twenty-five of the younger participants (33%) were on waiting lists for assessment in local services, while 19 (24%) had been seen for assessment only. The remaining participants had attended speech and language therapy services before the study, 18 (24%) had attended for short-term therapy (6 or less sessions) while 13 (17%) had attended for regular therapy (7 sessions or more) in the previous two years.

This group was matched by language ages and gender to participants in preschool and junior school studies. Matching by mental or developmental age equivalencies are frequently used in comparisons between children with Down syndrome and typically developing groups (Chapman, 1995). These were not used as the focus of the study was the exploration of the relationship between speech and language.

Typically developing participant pool

Data for the typically developing comparison group were obtained from preschool and school screening projects being run concurrently in association with community based speech and language therapists. These screening projects involved the assessment of speech and language skills in pupils in order to identify developmental levels and therapy needs in the population. The project was outlined to parents/ guardians by local therapists and written consent for participation was obtained using standard health board forms with an addendum stating that assessments would be carried out by qualified speech and language therapists or speech and language therapy students from the School of Clinical Speech and Language Studies, T.C. D. All pupils for whom consent forms were returned and who were present in the school on the designated screening date were assessed.

Participants selected

The data obtained from the screenings were scanned and participants for inclusion in the study were selected by language age matching. Data from screenings in two inner city preschools were used to match the Down syndrome participants (38) who were at language level 1 (24 – 42 months). Data from 37 pupils from three primary schools in the same area were randomly selected to match those at the later language levels (43-84 months). Adequate matching by language age (LA) was achieved (Mann Whitney U=- .58:p=0.5573). This resulted in differences in chronological age (CA) ranges with the DS ranging from 50 to 288 months while the TD group ranged from 24 to 98 months as shown by means, standard deviations and ranges in the box and whisker plot (Figure 4.5).

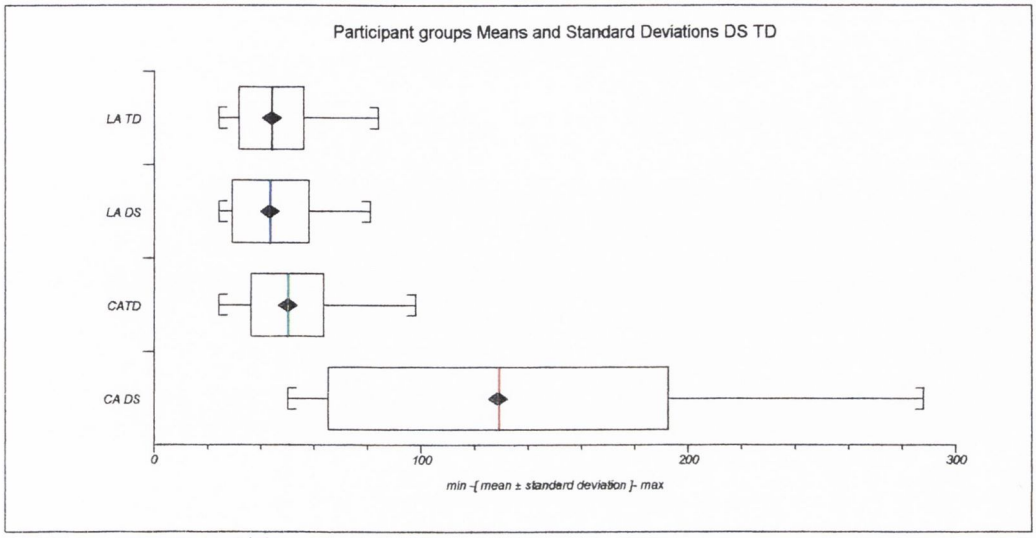


Figure 4.5 DS and TD groups: Chronological and language age spread

The chart demonstrates the major differences in chronological age range between the groups necessary to achieve language age matching but this was considered acceptable for the variables of interest in study 1, that is relationships between general language skills and development of speech intelligibility and the phonological system.

Characteristics

Access to medical and social information was restricted as these screenings took place in educational settings. Parental questionnaires and informal interviews with preschool staff and teachers indicated concerns that approximately ten per cent of the children were not speaking as well as others of their age group but no specific speech or language difficulties were identified.

Medical

School records did not indicate the presence of significant medical conditions. Screening developmental vision and hearing tests by public health nurses prior to admission to preschools and schools had not indicated severe visual or hearing impairment.

Social

Information on family composition, parental education levels and specific occupational status was not available for children in the school screening projects.

Socio-economic

Information from school records indicated that the occupational distribution was skewed towards occupations in Group 9 such as caretaking, construction and cleaning (I.S.C.O., 1990) with many parents unemployed. This information does not reflect the ability or educational aspirations of the parents as many were participating in community education and work training programmes. The area had been targeted for regeneration projects in social, educational and physical projects for three years before the screenings following a decade of high unemployment and social unease. The regeneration programmes used both formal and informal structures to develop knowledge and skills in the adults in the community and provided parental education and enriched environments for preschool children. It was felt that these factors should result in lower incidence and prevalence of communication impairments than would be expected from areas without these supports.

Developmental levels

Teachers of pupils who participated in the screenings reported no significant developmental delays in motor or social skills.

Educational placements

Children who participated in the screenings were attending two pre-schools and three national schools in an inner city area. These had been selected for screenings by school principals/managers in association with the local speech and language therapy services. They were located in areas of high unemployment with

histories of early school leaving and were participating in projects aimed at changing these profiles.

Previous speech and language therapy

None of the children had been referred to the speech and language therapy services prior to the screenings.

Disparities between the groups also existed in sensory functioning and in socio-economic status, which could impact on both general language achievements and on phonological system development. These factors could restrict the reliability of age related scores but should not significantly influence the exploration of the relationships between general language skills and speech development of interest in this study.

Data collected from the participants in Study 1 allowed the exploration of relationships between low speech intelligibility, phonological system development and language levels. Patterns of association between speech intelligibility and developmental levels in general language skills were examined within and across the two groups. Associations were explored across the groups across the language age range 24 to 84 months and separately by dividing the data into language age matched subgroups (participant characteristics are outlined in Appendix 5.1). Three levels were selected based on speech patterns reported in studies of typically developing children (Haelsig & Madison, 1986; Shriberg et al., 1994). The levels were associated with language age ranges as follows: -

- Language level 1 from 24 to 42 months
- Language level 2 from 43 to 62 months
- Language level 3 from 63 to 84 months

This division resulted in three unequal groups with 38 from each group at level 1, 29 at level 2, and 8 at level 3.

Studies 2 and 3: Participants

A subset (46) of the participants from the group with Down syndrome was selected by age range for Study 2. All of the eldest group, and 50% plus 1 from each other three age bands were selected randomly. Six of these failed to attend for the necessary number of data collection sessions (Three for health reasons and three to avail of speech and language therapy elsewhere). The 40 remaining participants provided data for studies 2 and 3.

Participant characteristics

Age range

The loss of three participants from the youngest group and one from each of the other groups resulted in slight differences in chronological and language age profiles between these and the group used in Study 1 as illustrated in figure 4.6.

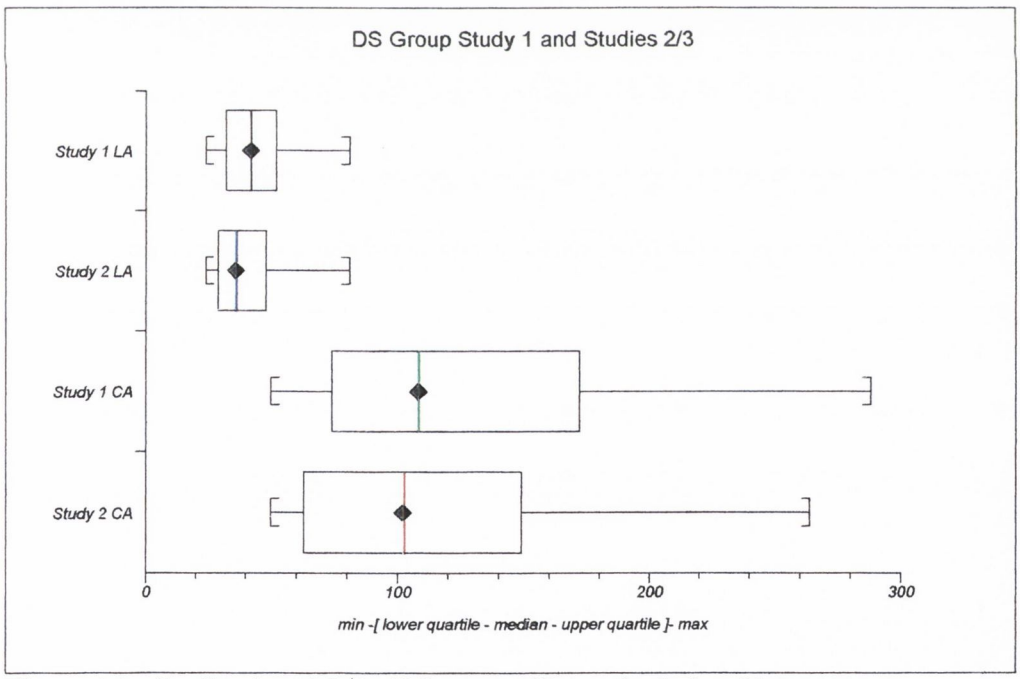


Figure 4.6. Studies 1 and 2/3: DS group: Chronological and language ages

There was a reduction in upper chronological ages (Study 1=288 months; Study 2/3=264) and a lowering of means from 128.81 to 113.77 and median scores from 108 to 102 in study 2/3 compared to study 1.

Language ages showed a similar reduction in mean and median scores (Mean from 43.37 to 39.75; median 42 to 36.) but no reduction in range or maximum scores.

Medical, developmental and social histories

Analysis of information available on the remaining group of 29 males and 11 females showed no significant differences in medical, developmental or family profiles between the subset and the group used in Study 1. All except one were living with two parents.

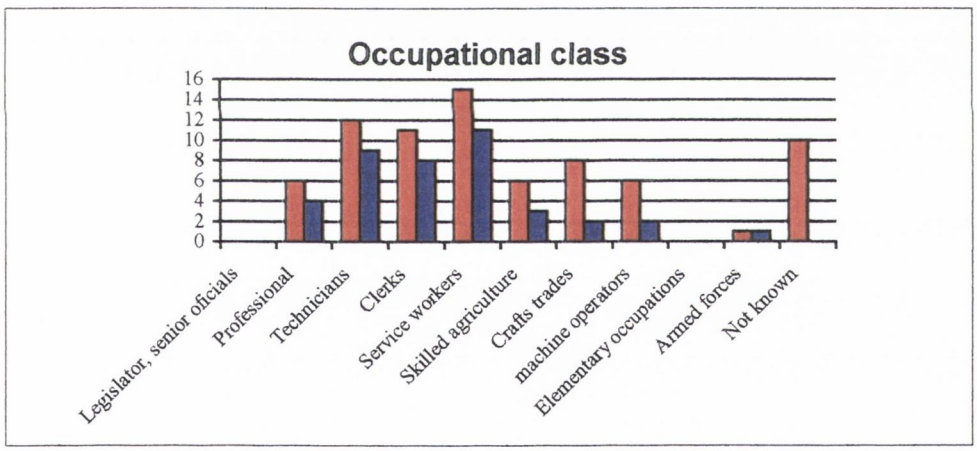


Figure 4.7: Study 1 and Studies 2/3: DS Group: Occupational grouping

The socio-economic grouping of those selected for studies 2/3 reflected the pattern found in the study 1 group.

Educational placements

A greater percentage of participants in studies 2/3 were attending integrated educational placements when compared to the study 1 group as seen on the table below.

Table 4.2 Participant educational and occupational placement

	Study 1	Studies 2/3
Pre-school (special)	13%	0
Pre-school	12 %	8%
National School (special*)	43%	40%
Primary School	20%	40%
Training centre	9%	5%
Work	3%	5%

* National schools designated as special provide both primary and secondary education pupils with special needs in the age range 4 -18 years

Previous speech and language therapy

Speech and language therapy histories indicated differences between the groups. Only two of the participants selected for studies 2/3 had attended for regular speech and language therapy prior to the study (5%, compared to 16% in the large group).

Study 3: Participant allocation to therapy and control groups

Participants were assigned randomly to immediate and deferred therapy groups. Group A (n=20) was designated as a deferred treatment group. Participants provided speech samples at time 1 and were waitlisted for therapy in the following school year, pre and post therapy samples were then obtained over a 10-month period. Group B (n=20) provided samples pre and post therapy over a ten month period.

Participants in Studies 2 and 3 provided data to allow exploration of relationships between speech intelligibility, phonological system development and development of other components of verbal language.

4.5 Description of tasks and measures

These studies required the use of tasks and measures which would provide data on the relevant components of verbal language and which were appropriate for use with the populations under study. Table 4.3 outlines the variables explored in the three studies.

Table 4.3 Variables explored in the studies

	Study 1	Study 2	Study 3
Intelligibility	✓	✓	✓
General language ability	✓	✓	✓
Receptive vocabulary		✓	✓
Phonological system	✓	✓	✓
Morphology		✓	✓
Syntax		✓	✓

The tasks and measures used are outlined below with detailed information on data collection and scoring presented in 4.6.

Factors influencing selection of measures

Speech and language therapists use a variety of formal and informal assessment procedures to measure the above components of language at both screening and diagnostic levels. Many of the available procedures were not however appropriate for use in this study due to the wide age range and life experiences of participants.

Measures were selected, adapted and devised to best reflect the competence of participants with the verbal code and to enable comparisons to be made across the groups. In order to do this it was necessary to consider the age range and social, motor and cognitive attributes of the participants.

a. Participant age range

Participants ranged in age from two years in the preschool screening studies to twenty seven years in the Down syndrome study. This wide age range imposed restrictions on time, procedures and materials. Sampling time was limited to one hour per participant in order to maintain optimal attention levels thus ruling out some of the more frequently used clinical assessment procedures.

b Social validity

Test materials and procedures were evaluated to ensure suitability for use across the wide age range. Many commonly used clinical procedures were ruled out as materials were found to be socially inappropriate for inner city children and /or the older participants in the Down syndrome group.

c Perceptual, cognitive and motor demands of test instructions and response modes

Previous research indicated that sensory, attentional, motor programming and cognitive difficulties occur with greater severity and frequency in children and adults with Down syndrome. Standardised assessments of speech and language which make high demands on sensory discrimination, cognitive processing or required rapid responses were ruled as inappropriate for the purpose of this study in order to minimise the effects of these constraints on expressive language sampling.

Materials, testing and scoring procedures from a selection of standardized tests in common clinical use were used to structure the sampling of relevant behaviours. Measures were devised for the studies where no suitable alternative was available.

4.5.i. Intelligibility (Studies 1, 2, 3)

Speech intelligibility measures are used clinically to evaluate the severity of speech impairment but there is little agreement on what aspect of intelligibility should be measured or how best this should be done. Kent, Mielo and Bloedel in a detailed review of available procedures concluded that there was little consensus on how intelligibility should be measured and that the process was 'fraught with procedural and interpretative complications' (1994: 81). A review of speech intelligibility measures devised for other clinical populations, for example those

with hearing impairment, acquired neurological disorders, and others, revealed that none were appropriate to the client group and the needs of this study.

Speech intelligibility was defined for the purpose of this study as clarity of speech as evaluated by family members, speech and language therapists and student observers. A five point linear scale with descriptors was devised in order to measure listeners' perception of intelligibility across a range of contexts (appendix 4.4.). General descriptors were chosen for the familiar listeners scale to encourage raters to evaluate intelligibility potentials across a range of communication contexts. A combination of general and clinical descriptors were used in the therapists' rating scale both to estimate intelligibility levels and to identify factors which could lead to a reduction in intelligibility in everyday communication situations.

4.5.ii. General Language ability (Studies 1, 2, 3)

The concept of general language was limited in the study to a global measure of language unifying conceptual, computational and pragmatic aspects in a developmental framework. The Preschool Language Scale–Revised (Zimmermann, et al., 1979) a norm referenced assessment in common clinical use was selected to sample this variable. The scales consist of two standardised subscales designed to measure auditory comprehension and expressive communication in children aged two to seven years or in older children functioning within this language age range. They are short, easy to administer and place low demands on perceptual, processing and responding skills and were deemed to be appropriate to the typically developing children and the older age range of the group with Down syndrome. The scales were selected for these studies in order to provide developmental language baselines during the period of maximal expressive phonological development that is 24 - 84 months.

4.5.iii. Vocabulary (Studies 2, 3)

The rapid expansion of vocabulary shown by typically developing children in the period between 2 and 8 years has been linked to the development of the formal components of language. Studies 2 and 3 sampled receptive and expressive vocabulary using the British Picture Vocabulary Scale (Dunn et al., 1982) for the former and a speech sample obtained using the Renfrew Action Picture Test (Renfrew, 1989) for the latter.

Receptive vocabulary

The British Picture Vocabulary Scale – B.P.V.S. (Dunn et al., 1982) is a standardized measure of receptive vocabulary. The scales provide a rapid measure of estimating understanding at a single word level with minimal processing and response demands. It was selected to measure comprehension of single word vocabulary and provide an estimate of stage of lexical development in the participants from the Down syndrome group in Studies 2 and 3.

Expressive Vocabulary

The Renfrew Action Picture Test (Renfrew, 1989) was developed to sample expressive language in children in the 3 – 7 year age range. The test uses pictures and questions to elicit verbal responses which are then scored and compared to vocabulary and grammatical scores obtained by a normative sample of over 500 children in the UK and Dublin in 1987. The vocabulary tables were used to estimate expressive vocabulary for this study.

4.5.iv. Phonological system (Studies 1,2,3)

As there is no single variable or measure that adequately reflects the phonological system, the studies measured selected aspects of the system in order to identify developmental status and compare these with the target language system. The

aspects selected were percentage of consonants correct, phoneme inventory, presence of developmental or atypical phonological processes, and process strength. Patterns of constraint rankings were used to identify general developmental levels.

Percentage of consonants correct scores are used clinically to measure the distance between a client's phonological system and the target language system. They are used to provide a measure of the degree of impairment or disorder severity (Edwards, 1994). Phoneme inventories also provide a relational measure allowing comparison of phonemes in the client's repertoire with those used in the target language. Process analysis allows evaluation of the client's system as an independent system and also allows comparison with the target language system. Constraint rankings and sonority hierarchy while not in common clinical use have been found useful in the identification of characteristics associated with communication impairment in individual case studies (Barlow & Gierut, 1999). Patterns of constraint rankings were used to identify general developmental levels.

Speech samples were structured in order to ensure that sufficient data on these aspects would emerge by using:

- Picture naming test
- Responses to expressive language items on all assessments
- Word and syllable imitation tasks
- Spontaneous speech sample obtained during unstructured obtained play and/or conversation.

Picture naming test

A picture naming test was developed for the study and was used to elicit production of singleton consonant phonemes, consonant clusters and polysyllabic at single word level (phonology probe). One hundred and twenty (120) words were selected from early vocabulary lists (appendix 4.5) to allow each consonant

phoneme to be sampled twice in syllable initial and final positions, at the beginning, in the middle and at the end of words. Consonant clusters and polysyllabic words were sampled by a further 60 words. The probe was piloted with typically developing pre-school children and was found to provide a rapid objective, replicable measure with high inter rater reliability. Test-retest reliability was established by use of the picture naming test and percentage of consonants correct (PCC) scores with twenty preschool children (age range 3-3.6) within a two week interval. Differences were observed in one child only who showed suppression of final consonant deletion of fricatives but as these were being signalled by stops at the second assessment his overall PCC score remained unchanged. Inter-rater agreement was checked by comparison of summary score sheets completed by test administrator and a speech and language therapy student. This comparison indicated complete agreement in 17 cases. Disagreement on the remaining three occurred on the identification of syllable final deletion, voicing and devoicing.

Participants were encouraged to name the probe pictures spontaneously with prompting and delayed imitation used if responses were not forthcoming. Samples obtained using the picture test allowed the participants use of singleton consonants to be compared to mature and developing language systems using percentage of consonants correct (PCC). Picture naming was selected as being a more appropriate method of establishing PCC than spontaneous speech samples with the populations in these studies. Clinical studies have indicated that those with speech impairments will often adapt and restrict their speech output by avoiding the use of vulnerable words to maximise communication efficacy. The word and syllable imitation task was devised and used alongside the picture naming test in order to ensure that all phonemes were sampled. In this task participants were asked to imitate all phonemes in 20 syllables and 40 words (appendix 4.7).

Naming of pictures to elicit consonant clusters and polysyllabic words from the picture test, imitation tasks, spontaneous speech samples and responses to

expressive language tests provided data to identify phoneme inventories, the number, type and strength of active developmental processes and to provide a developmental rating.

Phoneme inventory

Developing and impaired phonological systems may deviate from the target language phonemic inventory by restrictions in the number of phonemes available or used to signal contrasts. Use of a phonemic inventory atypical of the language e.g. non-native language phonemes or distorted sound realizations may compromise intelligibility. Phonemic inventories for participants in the study were established by analysis of speech samples and comparison to the inventory of the target language. All sounds produced contrastively in words were recorded on the summary sheets.

Table 4.4 Phoneme Inventory of the target language

	Syllable Initial (Word Initial)							Syllable Final (Word Final)					
	Bi labial	Labio dental	Inter dental	Dental alveolar	Palatal	Velar	Glo ttal	Bi labial	Labio dental	Inter dental	Dental alveolar	Palatal	Velar
Nasal	m			n				m			n		ŋ
Plosive	p b			t d		k g		p b			t d		k g
Fricative		f v	* θ ð	s z	ʃ				f v	θð	s z	ʃ*ʒ	
Affricate					tʃdʒ							tʃdʒ	
Approx -imant	w				lj		h					lɹ	

* /θ ð ʒ / restricted contexts

Inventories were rated as complete if all sounds were present and incomplete if phonemes were absent. Incomplete inventories were classified into early, middle and late developmental levels based on the phonemes present.

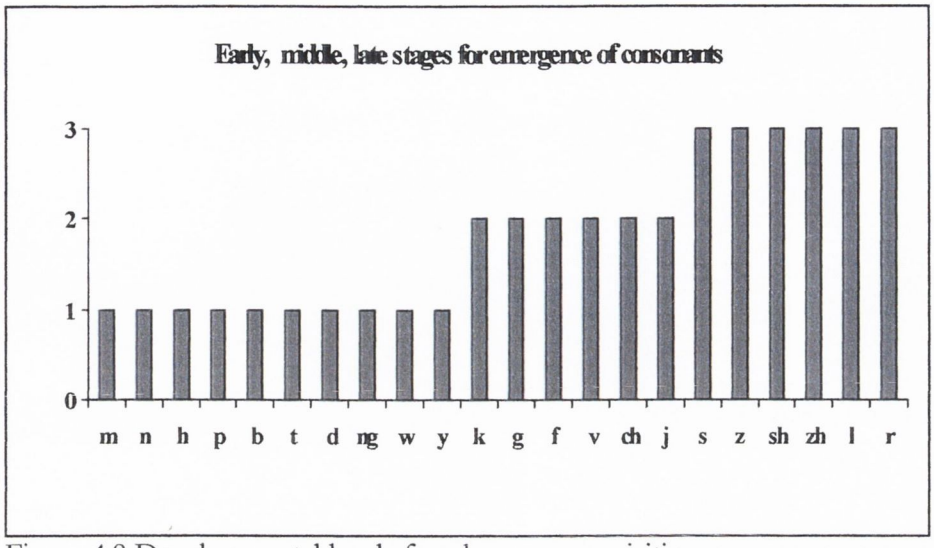


Figure 4.8 Developmental levels for phoneme acquisition

The developmental levels for phoneme inventories (figure 4.8) were based on findings from studies by Shriberg & Kwiatkowski (1994), Dodd (1995), and from developmental norm tables in Shipley & McAfee (1998).

Process analysis

Process analysis is used in clinical studies to identify the presence of developmental or atypical phonological processes in those presenting with impaired phonological systems. Process analysis categorises sound patterns across syllables and words and thus, 'they may reveal linguistically significant generalisation within and among speakers that might be missed at the phoneme or the feature level'.(Shriberg, 1994: 1139)

Clinically the term process has been defined as 'a systematic sound change that affects a class of sounds or a sequence of sounds' Edwards (1992: 235). A checklist of developmental processes was developed for this study from a review of the developmental literature and phonological process analysis procedures in clinical use (Tables 4.5-4.8). Speech samples were scanned to identify the number, strength and type of active phonological processes.

Syllable structure processes modify the shape of syllables or words. Samples were scanned for the occurrence of the 11 syllable structure processes listed in table 4.5.

Table 4.5 Structural Processes

Label		Description	Example
Unstressed / Weak syllable deletion	USD	Unstressed / weak syllables deleted in multisyllabic words.	banana→nana
Reduction to monosyllables	RM	Multisyllabic words reduced to single syllables.	banana →na
Reduplication	SR	Syllable or part syllable repeated to replace other syllables in words.	tʌmato→mamato
Final consonant deletion	FCD	Syllable final consonants within word or at word boundary deleted.	kʌp → kʌ
Initial consonant deletion	ICD	Initial consonants deleted within word or at word boundary	kʌp→ʌp
Cluster deletion	CCD	Clusters of two or more consonants deleted	bɹed → ed
Cluster reduction	CCR	Clusters of consonants reduced by deletion of one or more consonants	bɹed →bed
Epenthesis	E	Segment inserted into word - usually between elements of cluster	bɹed → biɹed
Reduction of unstressed syllable	RUS	Unstressed syllable reduced- usually to a vowel	banana → anana
Replacement of unstressed syllable	USS	Substitution of unstressed syllable by single sound or phonetic shape sound (favourite syllable)	banana→dənana təmato→dəmato
Reordering of segments (Metathesis / Migration)	MS	Position of two phonemes in word reversed / phoneme migrates to another position in a word	banana→ nanaba

Systemic processes reduce phoneme contrasts by changing place or manner of articulation. Samples were scanned for occurrence of 7 systemic place processes and 8 manner processes as outlined in table 4.6.

Table 4.6 Systemic processes: Place

Fronting	F	Sounds replaced by others produced further forward in the mouth – Subdivided as follows;	
De-palatalization	DEP	Palatals fronted-usually to alveolars	ju→lu
Fronting of velars	FV	Velar sounds replaced by alveolars	kʌp→tʌp
Alveolarization	A	Interdental /labial sounds replaced by alveolars	fat →sat
Labialization	LAB	A nonlabial sound is replaced by a labial	ʃu →pu
Backing	B	Front consonants are realised as velars or palatals	ʃu →ku
Backing +	B+	Front consonants replaced by uvular and / or pharyngeal sounds (fricatives and /or plosives)	ʃu→χu gol→ ʔol noz →noɣ
Glottal replacement	GR	Consonants replaced by glottal fricative or stop	ʃu→ hu noz →no
Systemic sound preference / Favourite sound	SSP	Replacement of whole class of phonemes or of several phonemes across class boundaries by a single phoneme.	ʃu su zu tu→ bu

Table 4.7: Systemic processes: Manner

Stopping	S	Fricatives/ affricates replaced by stops at the same place of articulation	ʃu→tu tʃu→tu
Affrication	AFF	Fricatives replaced by affricatives [Partial stopping process]	ʃu→ tʃu
Gliding liquids	GL	Liquids replaced by glides	læm →jæm
Gliding other than liquids	GO	Fricatives, etc. replaced by glides	ʃu → wu
De-affrication	DAF	Affricates replaced by fricatives	tʃu →ʃu
Nasalization	N	Oral consonants replaced by nasals	ʃu → nu
Denasalization	DN	Nasal consonants realised as oral stops / liquids, etc.	noz → doz
Lateralization	L	Lateral fricative used in place of forward release in fricatives / affricates	ʃu→ ɬu
Voicing*	V	Voiceless consonants voiced preceding vowel – devoiced in final position	ʃu → ʒu noz→ nos

*Voicing was counted under manner processes if the sample indicated systematic application to a class of sounds. Inconsistent voicing / devoicing was counted under assimilatory processes below.

Assimilation or harmony processes describe the influences of sounds on each other within word and across word and syllable boundaries. Assimilation may be partial or complete, progressive or regressive. Speech samples were scanned to identify occurrences of the following assimilation processes.

Table 4.8: Assimilation Processes

Velar assimilation	VA	Consonants become velarised under the influence of a nearby velar sound	dog⇒gog
Labial assimilation	LA	Consonants become labialised under the influence of a nearby labial sound	kʌp⇒ pʌp bed ⇒ beb
Nasal assimilation	NA	Consonants become nasalized under the influence of a nearby nasal sound.	banana⇒ nanana
Alveolar assimilation	AA	Consonants become alveolar under the influence of a nearby alveolar sound	bed ⇒ ded
Liquid assimilation	LiA	Consonants move towards liquids under the influence of a nearby liquid sound.	ɔlipɔp⇒ ɔlilɔp
Vowel place / manner assimilation	Vo.P	Consonants may be influenced by neighbouring vowels in both place and manner aspects	lʌv ⇒ lʌz
Prevocalic voicing	PV	Voiceless consonants become voiced due to the influence of a preceding vowel	ʃu ⇒ ʒu
Final devoicing	DV	Final consonants become devoiced as vowels assimilate to silence.	dog ⇒dok

Process strength

Developmental research studies have indicated that the influence of phonological processes on developing phonological systems is reduced in a gradual manner. The waning influence can be seen in the gradual limitation of the number of sounds or sound classes influenced by a process. Process strength was used in this study to measure these developmental changes in the strength and influence of phonological processes. It was measured by the identification of the number of phonemes influenced by the processes active in each participant's speech.

System rating

Optimality Theory was used to provide a framework to identify and explore levels of the phonological system development in the participants from the group with Down syndrome. Optimality theory proposes that all language learners begin with a grammar in which constraints against marked structures outrank faithfulness constraints (Markedness constraints dominate Faithfulness constraints). This grammar is universal and produces maximally unmarked forms resulting in outputs differing from inputs. The language learner's task is to promote the constraints required to be faithful to the ambient language above the universal markedness constraints. Developmental patterns are evident in changes in constraint rankings as the child's output moves towards the adult patterns. The analyses and rating scale designed for this study explores the relative rankings of a selection of markedness and faithfulness constraint. Detailed analyses using optimality frameworks to explore interactions between constraints were not considered feasible due to restricted resources and the clinical nature of the research project. The constraints and proposed rankings were selected from those described in the acquisition and cross-linguistic literature. (Gnanadesikan, 1995; McCarthy & Prince, 1994; Prince & Smolensky 1993; Smolensky, 1996b; Tesar & Smolensky, 1998).

Two additional factors were incorporated into the rating scale to capture any possible effects of protracted system development in a population presenting with low speech intelligibility.

i) Generic constraints were divided into subgroups using the sonority hierarchy (Blevins, 1995; Steriade, 1997, 2000) to capture incomplete rankings in developing phonological grammars. This resulted in three NO CODA constraints to discriminate constraints against plosive, fricative or other consonants in syllable final position. NO COMPLEX was divided into two families with /s/ clusters differentiated from other complex syllable onsets.

ii) A generic constraint against articulatory precision was included in the rating scale as the literature review indicated that articulatory factors at the phonetic segment or sequencing level were to be expected in the population under study. This constraint covers a range of articulatory constraints with a possible functional basis as outlined by Boersma (1999).

The constraints and their rankings are defined below and summarised in table 4.14.

a) NO CODA

Open syllables have been found to be preferred in early acquisition (Ingram, 1989) and many languages do not allow final consonants (Blevins, 1995). Outputs that include a final consonant violate the markedness constraint NO CODA (McCarthy & Prince 1995). This constraint is dominated by the faithfulness constraint MAX (no deletion) in a mature English grammar but the reverse rating is often seen in child language. Conflicts between constraints and the possible output forms are shown formally by constraint tableaux in optimality theory. The tableau below illustrate the major rankings only.

Table 4.9 Learner and mature rankings of * CODA in English

Learner	*CODA>>MAX			Mature	MAX >>* CODA	
Cup /kʌp/	*CODA	MAX		Cup /kʌp/	MAX	*CODA
/kʌp/	*!			☞/kʌp/		
☞/kʌ/		*		/kʌ/		*

Notation >>= dominates: ☞= Optimal candidate: *! = Fatal violation eliminating candidate: * = constraint violation: Shaded cell = inactive constraint

The tableau above illustrates the conflict between NO CODA and MAX (no deletion) in learner and mature rankings in English. The pointing finger indicates the optimal candidate that is the one which best satisfies the top-ranked constraint on which it differs from its competitors. The learner shows *CODA dominating MAX with the final consonant deleted from the optimal output. The

mature grammar has elevated MAX above *CODA and thus the output form matches the input.

Ranking

*CODA>>MAX Speech samples were analysed to identify rankings of

- No Coda / plosive >> Max
- No Coda / fricative >> Max
- No Coda Other >> Max.

b. NO COMPLEX /s/

Consonant clusters are considered to be marked relative to singletons, occur less frequently in languages and appear later in acquisition. The markedness constraint *COMPLEX dominates the faithfulness constraint MAX resulting in deletion of an element of the cluster as illustrated in the tableaux below.

Table 4.10 Learner and mature rankings of *Complex S

Learner	*COMPLEX>>MAX			Mature	MAX>>*COMPLEX	
Sleep /slip/		MAX			MAX	*COMPLEX
/slip/	*!			☞/slip/		*
☞/sip/		*		/sip/	*!	

Ranking: * Complex S >> Max

c. NO COMPLEX O

Clusters with liquids and glides as a second element are also reduced due to the influence of * COMPLEX in first and second language acquisition.

Table 4.11 Learner and mature rankings of * COMPLEX O

Learner	*COMPLEX >>MAX			Mature	MAX>>*COMPLEX	
blow /blo/	*COMPLEX	MAX			MAX	*COMPLEX
/blo /	*!			☞/blo /		*
☞/bo/		*		/bo/	*!	

Ranking: * Complex O >> Max

d. NO DORSAL

Velar / dorsal consonants are perceived as more marked than coronals and a segmental markedness constraint * DORSAL has been reported in developmental literature (Smolensky, 1996a). Ranking of * DORSAL above MAX will result in velar consonants being realized as coronal in the pattern of fronting frequently described in children with low speech intelligibility.

Table 4.12 Learner and mature rankings of * DORSAL

Learner	ONSET >> *DORSAL >> IDENT Feat / place				Mature	ONSET >> IDENT Feat / place>>** DORSAL		
Key /ki/	ONSET	*DORSAL	IDENT Feat / place			ONSET	*IDENT Feat / place	* DORSAL
/ki /		*!			☞/ki/			*
/i/	*!		*		/i/	*!		
☞/ti/			*		/ti/		*!	

Ranking: * DORSAL >> IDENT Feat / place

e. NO CORONAL

A constraint against coronals was included in the rating scale to account for the process of backing of tongue blade sounds frequently reported in children with impaired / restricted phonological systems (Cheung & Abberton, 2000). This

constraint conflicts with markedness theory but was included as a possible marker of speech impairment.

Table 4.13: Learner and mature rankings of * CORONAL

Learner	ONSET >> *CORONAL >> IDENT Feat / place				Mature	ONSET >> IDENT Feat / place		
Tea /ti/	ONSET	*CORONAL	IDENT Feat / place			ONSET	*IDENT Feat / place	*COR.
/ti /		*!			☞/ti/			*
/i/	*!		*		/i/	*!		
☞/ki/			*		/ki/		*!	

Ranking: *Coronal >> IDENT Feat/ place

f. NO FRICATIVE

Fricatives are rarely deleted in child phonology but are frequently substituted by plosives (Barlow & Gierut, 1999). This pattern is captured in optimality theory by the ranking of a markedness constraint against fricatives above the faithfulness constraint IDENT Feat / manner which seeks to preserve the correspondence between input and output in manner of articulation. Segment substitution rather than deletion is necessary in order to satisfy MAX ONSET, which prohibits deletion of initial segments in syllables.

Table 4.14 Learner and mature rankings of *FRICATIVES

Learner	ONSET >> *FRICATIVE >> IDENT Feat / manner				Mature	ONSET >> IDENT Feat / manner >>*FRICATIVES		
Sea /si/	ONSET	*FRICative	IDENT Feat / manner			ONSET	*IDENT Feat / manner	*FRICative
/si /		*!			☞/si/			*
/i/	*!		*		/i/	*!		
☞/ti/			*		/ti/		*!	

Ranking * Fricative >> IDENT Feat / manner

g. NO LIQUID

Liquid consonants are considered as marked by their low frequency of occurrence cross - linguistically and late acquisition in developing phonologies (Barlow & Gierut, 1999). *LIQUIDS may result in deletion of the liquid segment as in late / leit/ to /eit/ but more frequently results in their realization as a glide /leit/ to /weit/ to preserve onset.

Table 4.15 Learner and mature rankings of * LIQUIDS

Learner	ONSET >> *LIQUID >> IDENT Feat / manner				Mature	ONSET >> IDENT Feat / manner >>*LIQUID		
Rain /Jein/	ONSET	*LIQUID	IDENT Feat / manner			ONSET	*IDENT Feat / manner	*LIQ.
/Jein/		*!			☞/Jein/			*
/ein/	*!		*		/ein/	*!		
☞/wein/			*		/wein/		*!	

Ranking * Liquid >> IDENT Feat/ manner

h. No Articulatory precision

Patterns of phonetic or allophonic substitutions at segment or syllable were included in this category. The following substitution patterns at segment level were included:

- Lateral release on fricatives and affricates
- Gliding /J/ in limited phonetic environments (pre / post rounded vowels, syllable boundary within word)
- Deaffrication

Inconsistent patterns at syllable or word level were also included in this category.

Ranking *Artic precision >> IDENT Feat place / manner

Table 4.16: Constraints and rankings used to establish developmental levels

Constraint	Ranking	When this ranking applies
* Coda plosive	* Coda plosive >> Max	Cake /keik/ ☞ /kei/
* Coda fricative	* Coda fricative >> Max	Case /keis/ ☞ /kei/
*Coda other	* Coda nasal /liquid >> Max	Came /keim/ ☞ /kei/
* Complex S	* Complex S >> Max	Steak /steik/ ☞ /teik/
* Complex O	* Complex O >> Max	Flake /fleik/ ☞ /feik/
* Dorsal	* Dorsal >> IDENT Feat /place	Cake /keik/ ☞ /teit/
*Coronal	*Coronal >> IDENT Feat / place	Take /teik/ ☞ /keik/
* Fricative	* Fricative >> IDENT Feat / manner	Sake /seik/ ☞/ teik/
* Liquid	* Liquid >> IDENT Feat / manner	Lake /leik/ ☞/weik/
*Artic precision	*Artic precision >> IDENT Feat place / manner	Sake /seik/ ☞ /ɬeik/

Speech samples were scanned to identify rankings of the above constraints to provide approximate levels of system development.

4.5.v. Morphology and syntax (Studies 2, 3)

The Test of Auditory Comprehension of Language-Revised (Carrow-Woolfolk, 1985) measures comprehension of receptive vocabulary, morphology, and syntactic structures with minimal processing or response demands. Understanding of morphology was assessed using the second subtest Grammatical Morphemes. This subtest explores understanding of pronouns, prepositions, and noun and verb inflections. The third subtest, Elaborated Sentences, was used to estimate understanding of simple and complex sentence structures.

Expressive Grammar

The speech sample obtained from the Renfrew Action Picture Test (Renfrew, 1989) was used to measure morphological and syntactic structures. The grammar scoring procedure was adapted to allow variations in sentence and word structures to emerge. These modifications are detailed in the next section. This procedure was used instead of morpheme count, mean length of utterance or full syntactic analysis of a spontaneous speech sample, because of the low speech intelligibility levels of participants in the group with Down syndrome.

4. 5.vi. Additional measures used with participants in Studies 2/3

a. Oral structure and functioning

A standard visual examination of oral structures was carried out. Oral functioning was evaluated by observation of lip, tongue and velar movements. The Fletcher diadochokinetic examination format (Fletcher, 1978) was used to sample oral movement rate and range. Procedures were modified by providing visual cues to encourage rapid repetition. Standardised scoring procedures were not appropriate. Raw scores were noted in terms of number of repetitions achieved and time taken Sequential articulatory movements were evaluated in words by counting the number of correct repetitions of the word 'buttercup'.

b. Auditory acuity

Hearing was screened at 30 dB using an audiometer in a reasonably quiet clinic room.

4.6. Data collection and analysis

4.6. Data collection

A professionally qualified speech and language therapist and / or a speech and language therapy student assessed the participants in all studies. Assessments, which were carried out by students were observed and scored by therapists. Participants from the group with Down syndrome attended for assessment in a speech and language therapy clinic. Participants in the screening projects were assessed in reasonably quiet rooms or shared spaces adjacent to their classrooms. One hour was allowed for completion of all assessments in Study 1.

Data for Study 2 were gathered during a one-hour assessment followed by two shorter sessions (30 minutes maximum), which were incorporated into therapy sessions. The additional time was required for assessments of vocabulary, morphology and syntax. Tests and sampling procedures were structured in the order that was deemed most suitable to the participant and the data required for the study.

Sampling procedures for Study 3 were similar to Study 2 and occurred at two time points for group B and three for group A. Measurements (M 1) were obtained from both groups at time one. Group B commenced therapy (T) within two months and attended for 20 sessions over a seven to eight month period while group A was waitlisted for therapy (WT) with no direct intervention for 12 months. Measurements (M 2) were repeated for both groups at this point. Group A then commenced therapy and attended for 20 sessions over a seven month period. A final set of measurements (M3) was obtained from this group within two months of completing therapy.

Table 4.17: Summary of data collection points Study 3.

	Time 1	11–14 months	Time 2	12 months	Time 3
Group A	M 1	T	M 2	T	M 3
Group B	M 1	WT	M 2		

All assessment sessions provided opportunities for conversation and play in order to elicit a sample of spontaneous speech. The Symbolic Play Test (Lowe & Costello, 1976) and a selection of toys were used with younger children while story sequencing cards and personal narratives were used with the adolescents and adults.

4.6.i Data recording and scoring: Intelligibility Rating Scale

Parents were asked to rate the intelligibility of their son's or daughter's speech in everyday situations and to mark this rating on the scale below. They were asked to base their rating on how well their child got messages across using speech with both family and friends.

Table 4.18: Intelligibility rating scale: Parent Rating

1	2	3	4	5
Speech understood by family only. Many sounds mispronounced and omitted.	Speech unintelligible. Gestures needed to get messages across.	Speech understood by familiar people when topic is known.	Speech understood by others most of the time but some sounds not pronounced correctly and occasional misunderstandings occur.	Speech easily understood. No speech sound errors.

The therapist and student completed the therapist rating scale following the assessment session. This rating was based on speech samples from formal assessments and conversational speech.

Table 4.19 Intelligibility rating scale: Speech and language therapist rating

1	2	3	4	5
Unintelligible speech. Gestures and intonation patterns needed to convey meanings.	Essentially unintelligible. Limited repertoire of consonants used contrastively. Structural processes present	Partly intelligible if topic is known and context shared. Structural and systemic processes present.	Generally intelligible. Residual errors primarily in manner e.g. Stopping, Deaffrication, Cluster reduction	Speech fully intelligible. Complete phonological system.

Scores from both scales were combined to provide a combined intelligibility rating in the range 1 to 10. Intelligibility Ratings represent averaged scores from parent / carer and speech and language therapists rating scales.

Reliability of Intelligibility rating scales

Ratings completed during assessment sessions by tester and observer were compared and a joint rating agreed. This rating was further checked against a second blind rating by a therapist on the video recordings of 10 participants with only one difference noted. Inter rater agreement was calculated for parent and speech and language therapist ratings on the scales and was found to be high (r. = 99)

4.6.ii. Data collection: General language ability

The Preschool Language Scale – Revised (Zimmermann et al., 1979) was administered and scored for overall language age following procedures outlined in the manual. Raw scores were converted to age equivalent scores using the norm tables. Age equivalency scores were used in Study 1 to evaluate developmental patterns in speech intelligibility for the age range 24 –84 months.

In studies 2 and 3 age equivalency scores were converted to rated scores to facilitate evaluation of relationships between language skills, phonology, morphology and syntax. The rated scores were derived as outlined below.

Table 4.20: Rated language scores

PLS Age equivalent scores	Language level	**Language rating**
Below 24 months		**0**
24-30	1	**1**
31-36		**2**
37-42		**3**
43-48	2	**4**
49-54		**5**
55-62		**6**
63-68	3	**7**
69-74		**8**
75-78		**9**
79-84		**10**

4.6. iii. Data collection: Vocabulary

The British Picture Vocabulary Scale (Dunn et al., 1982) was administered and scored following manual procedures. Scores were converted to age equivalency scores for receptive vocabulary. Age equivalency scores were converted to rated scores as indicated below to facilitate comparison between vocabulary and phonology.

Table 4.21: Rated scores: Receptive Vocabulary

BPVS - Age equivalent scores	**Receptive vocabulary rating (RVR)**
<24 months	**0**
24-30	**1**
31-36	**2**
37-42	**3**
43-48	**4**
49-54	**5**
55-62	**6**
63-68	**7**
69-74	**8**
75-78	**9**
79-84	**10**

Expressive Vocabulary

The Renfrew Action Picture Test (Renfrew, 1985) was administered and raw scores obtained using materials and procedures as outlined in the manual. Raw scores were converted to rated scores, as the standardised scores in the manual did not cover the lower language levels expected to occur in the studies. Raw scores were converted as follows:

Table 4.22: Rated scores: Expressive vocabulary

Vocabulary RAPT raw scores	**Expressive vocabulary rating**
0	**0**
1-5	**1**
6 -10	**2**
11-15	**3**
16-20	**4**
21-25	**5**
26-30	**6**
31-35	**7**
36-40	**8**
41+	**9**
41+	**10**

4 .6.iv. Data collection: Phonological system

The studies measured aspects of the expressive phonological systems of participants in order to compare these with the dominant target language system. Assessment sessions were structured to ensure that the speech samples obtained would provide a fair representation of each participant's speech.

Spontaneous speech samples were obtained by allowing for a minimum of 10 minutes unstructured play and/or conversation during the assessment sessions. Recordings of the assessment sessions were scanned to identify phonemic inventories, number of processes active and process strength in spontaneous speech samples and in responses to expressive language items. Sampling was structured by using a picture naming test, syllable and word imitation task and responses to expressive language assessments.

Picture naming test

Participants were asked to name the pictures presented in a book format. Spontaneous naming was encouraged with semantic prompting used if participants did not appear to recognise the pictures. Prompts described the object initially and, if these failed to elicit the target, delayed imitation was used. Responses were transcribed on the recording sheet using broad phonemic transcription. Audio and/or video recordings were used to check accuracy of live recording. Responses were summarised on a form devised to facilitate calculation of percentage of consonants correct (PCC), to identify process number and type, and to record phoneme inventories. The form is reproduced in full in Appendix 4.5) and with key features summarised in Tables 4.23 and 4.24.

Table 4.23: Phonology probe: Individual record sheet

PROBE					**PROBE + SAMPLE**				
	C to adult system				**C to adult realisation**			**Processes**	**Phonemes**
Target	S.I.	WwF	WwI	SF	SI	WW	SF	Structural	
p								UsD	
b								FCD	
t								ICD	
d								CCD	
k								CCR	
g								MS	
Ø	-	-	-	-				Other	
δ	-	-	-	-					
f								Assimilation	
v								NA	
s								LA	
z								Other	
ʃ								Systemic P.	
ʒ	==		==	-				F	
tʃ								B	
d3								SSP	
m								Other	
n								Systemic M.	
ŋ	==		==					S	
w		==		==				DA	
l								GL	
r								GO	
j		==		==				N	
h		==		==				L	
Total								V	
Max.	40	44		36				Other	

P.C.C. = ____ 100= _____%. No. of processes _____

120 No. of phonemes _____

Table 4.24 Consonant clusters and polysyllabic words

	S.I.	WW	S.F.	Process	Pollysyllabics
pr		====	====		football
pl		====	====		bucket
br		====	====		banana
bl		====	====		buttercup
tr		====	====		tomato
tw		====	====		potato
dr		====	====		butterfly
dw		====	====		helicopter
kr		====	====		dinosaur
kl		====	====		octopus
kw		====	====		vegetable
gr		====	====		hospital
gl		====	====		lemonade
gw	==		====		Other:
fr		====	====		
fl		====	====		
sp					
st					
sk					
sw		====	====		
sl		====	====		
sm		====			
sn		====	====		
spr		====	====		
spl		====	====		
str		====	====		
skr		====	====		
skw		====	====		

Measures derived from speech samples

Percentage of consonants correct (PCC)

Data from the phonology probe were used to compare the participants' system to the native language system using percentage of consonants correct. PCC scores were calculated by counting as correct all productions in the naming test that were consistent with the target language system.

P.C.C. = $\frac{\text{\_\_\_\_\_}}{120}$ **X 100 =** _____ **%**

Consonant Correct Rating

Percentage of consonants correct scores were converted to rated scores by dividing scores by 10 for comparison with language measures in studies 2 and 3.

Process analysis

Speech samples obtained from the picture naming, responses to expressive language assessments and spontaneous speech were scanned to identify the number and types of processes present. Processes identified were classified into process types, as described in 4.6.v and outlined in table 4.25 (appendix 4.6). The data obtained were analysed in terms of number of each type of process present and total number of processes.

Table 4.25. Process summary sheet

	Syllable structure processes	Phonemes influenced
USD	Unstressed/weak syllable deletion	
RM	Reduction to monosyllables	
SR	Reduplication	
FCD	Final consonant deletion	
ICD	Initial consonant deletion	
CCD	Cluster deletion	
CCR	Cluster reduction	
E	Epenthesis	
RUS	Reduction of unstressed syllable	
USS	Replacement of unstressed syllable by single sound/ syllable	
MS	Reordering of segments	
	Other	
	Total present	Total influenced:

Systemic Place Processes		
F	Fronting	
DEP	De-palatalization	
FV	Fronting of velars	
A	Alveolarization	
LAB	Labialization	
B	Backing	
B+	Backing +	
GR	Glottal replacement	
SSP	Systemic sound preference / Favourite sound	
	Other	
	Total present	Total influenced:

Systemic Manner Processes		
S	Stopping	
AFF	Affrication	
GL	Gliding liquids	
GO	Gliding other than liquids.	
DAF	De-affrication	
N	Nasalization	
DN	Denasalization	
L	Lateralization	
V	Voicing	
	Other	
	Total present	Total influenced:

Assimilation/harmony processes		
VA	Velar assimilation	
LA	Labial assimilation	
NA	Nasal assimilation	
AA	Alveolar assimilation	
LiA	Liquid assimilation	
Vo.P	Vowel place assimilation	
PV	Prevocalic voicing	
DV	Final devoicing	
	Other	
	Total present	Total influenced:

Number of Processes

The number of processes present was identified and classified by type to explore the relationships between process type and speech intelligibility. Process number scores were rated from a base of 20 + to a ceiling of 0 where all non-native processes were suppressed.

Table 4.26: Rating for number of processes

Number of processes	Rating
19 – 20 +	**0**
17-18	**1**
15-16	**2**
13-14	**3**
11-12	**4**
9- 10	**5**
7 -8	**6**
5- 6	**7**
3-4	**8**
1- 2	**9**
0	**10**

Process strength

The term process strength was used in these studies to label the influence of phonological processes on the phonemes in the participants' phonological systems as they moved towards the target language system. The possible number of phonemes open to influence was restricted to 21 for the purpose of calculating process strength. The phonemes /θðʒ/ were omitted because of low occurrence rate in the lexicon expected for the age range under study. The strength of phonological processes on the participants' system was calculated by counting each phoneme influenced by any process once. This yielded scores between 0 and 21. Zero scores indicated that all target language phonemes had been established while a score of 21 indicated that a stable base for the target language system had not yet developed. Rated scores were calculated as outlined in table 4.27.

Table 4.27: Process strength rating

Process strength	**Rating**
19+	**0**
17-18	**1**
15-16	**2**
13-14	**3**
11-12	**4**
9- 10	**5**
7 -8	**6**
5- 6	**7**
3-4	**8**
1- 2	**9**
0	**10**

Phonological system developmental ratings

Speech samples were analysed and constraint rankings identified. Each instance of a markedness constraint dominating faithfulness scored a single point. The total score provided a coarse estimate of the degree to which markedness constraints enforced unmarked structures. High scores indicated systems where faithfulness constraints were dominated by markedness constraints. The higher the developmental rating score, the greater the predicted disparity between the child output rankings and those of the adult speakers of the language.

Table 4.28: Constraints and rankings used to establish developmental rating

Constraint	Ranking
* Coda plosive	* Coda plosive >> Max
* Coda fricative	* Coda fricative >> Max
* Coda other	* Coda nasal /liquid >> Max
* Complex S	* Complex S >> Max
* Complex O	* Complex O >> Max
* Dorsal	* Dorsal >> IDENT Feat/place
*Coronal	*Coronal >> IDENT Feat/ place
* Fricative	* Fricative >> IDENT Feat / manner
* Liquid	* Liquid >> IDENT Feat/ manner
Artic precision	*Artic precision >> IDENT Feat place / manner

The developmental rating obtained was used to explore relationships between phonological system development and other components of language in the Study 2 and to explore patterns of change in Study 3.

Phoneme inventory

Phonemic inventories for participants in the studies were established by the analysis of data obtained from the picture naming test responses, word and syllable imitation tasks and spontaneous speech samples. Phonemes present were identified and compared to the inventory of the target language as outlined in table 4.29.

Phonemes were scored as present if they occurred and served a contrastive function in any utterance (spontaneous or imitated) during the assessment session. This procedure was selected to allow the inventories to reflect the range of consonants available to the participants for use in speech.

Table 4.29: Target Phonemic Inventory

Syllable initial	Bilabial	Labio dental	Inter dental	Dental alveolar	Palatal	Velar	Glottal
Nasal	m			n			
Plosive	p b			t d		k g	
Fricative		f v	θ ð	s z	ʃ		
Affricate					tʃdʒ		
Approximant	w				lɹj		h

Syllable final	Bilabial	Labio dental	Inter dental	Dental /alveolar	Palatal	Velar
Nasal	m			n		ŋ
Plosive	p b			t d		k g
Fricative		f v	θð	s z	ʃʒ	
Affricate					tʃdʒ	
Approximant					lɹ	

Optional θ ð ʒ for some dialects

Inventories were rated as complete if all sounds were present, and incomplete if phonemes were absent. Incomplete inventories were classified as developed to

early, middle and late developmental levels based if 80% of phonemes for that level and preceding levels were present.

Table 4.30: Phoneme inventory developmental levels

Rating	Level	Phonemes (80%)
0		Less than 80% of phonemes for level 1 present
1	Early	m n h p b t d w j ŋ
2	Middle	k g f v tʃ dʒ
3	Late	s z ʃ ɹ l θ ð ʒ.*

*θ ð ʒ. Excluded from calculation because of low occurrence rate in the lexicon expected for the age range under study.

Reliability: Transcription and scoring of speech measures

As the studies involved participants with low speech intelligibility and the use of informal assessment materials the reliability of transcriptions and scoring of speech measures was controlled for and evaluated as follows:

Samples were transcribed broadly using the symbols of the International Phonetic Association (IPA) by tester and observer during the assessment session. Agreement between observer and tester were checked following the session and differences resolved using recorded materials where necessary.

Inter rater reliability was calculated for scoring of percentage of consonants correct, number and type of processes present for 20 participants from the DS group based on the picture naming test. Twenty video recordings of participant performance on the naming test were randomly selected and scored by the researcher and two speech and language therapy colleagues. Percentage agreement was found to be high for percentage of consonants correct scores (96.7%) and Process number count (98%). Agreement on process type was moderately high at 89.3 %. Disagreement was found to occur mainly on systemic sound preference and prevocalic voicing.

4.6.v. Data collection and scoring: syntax and morphology

Receptive morphology and syntax

Two sections of the Test of Auditory Comprehension of Language–Revised (Carrow-Woolfolk, 1985) were used to measure comprehension of morphology (section 2), and syntactic structures (section 3). Standard instructions and materials were used. Test administration was modified by increasing the test ceiling to 10 errors. This was to ensure that a cross section of structures would be sampled. Raw scores were converted to rated scores using age equivalency scores from the administration manual.

Table 4.31: Rating for receptive morphology and syntax

Morphology raw score	**Rating**	Syntax raw score
1-3	**0**	1-2
4-6	**1**	2-5
7-11	**2**	6-8
12-15	**3**	9-11
16-18	**4**	12-14
19-22	**5**	15-18
23-26	**6**	19-21
27-30	**7**	22-24
31-32	**8**	25-28
33-34	**9**	29-31
36-40	**10**	32-40

Expressive morphology and syntax

A speech sample was obtained using the Renfrew Action Picture Test (RAPT: Renfrew, 1989). Standardized administration procedures were followed but scoring of grammar was modified to allow variations in sentence and word structures to emerge and key developmental features to be identified.

Morphology

A checklist of morphological markers (List 10) was adapted from available developmental checklists (Brown, 1973; Crystal, Fletcher & Garman, 1982; Lee 1974; Miller & Chapman, 1981, Miller 1988) in order to explore morphological complexity. Responses were scanned and a score of one point was allocated for any one usage of noun and verb inflections and for prepositions, pronouns and determiners as summarised in table 4.32.

Table 4.32: Rated scores for expressive morphology

Rating		Morphology
1	One point for each type used	Preposition - any
2		Pronouns- any
3		Determiner- any
4		Regular plurals- any
5		Possessive -s
6		Regular past tense
7		Auxiliary –contracted / uncontracted
8		Present -ing
9		Verb number (3s)
10		Copula – contracted / uncontracted

Syntax rating

The syntax rating scale was devised to capture developmental patterns at phrase, clause and sentence level. Minor responses and stereotype utterances were ignored. Major responses to each picture were scored to identify

- Key semantic roles expressed syntactically, e.g. action agent,
- Phrase structure markers used
- The emergence of multiple clause utterances.

These were scored according to the criteria below.

Results were totalled and divided by 10 to provide the rating for syntax.

Table 4.33: Rating for expressive syntax

Sentence structure	Score
One element i.e. noun, verb, adjective, e.g. teddy	2
Two elements e.g. kiss teddy OR One element expanded e.g. bold dog	4
Two element + NP or VP expansion e.g. kissing her teddy	6
Three element +/- expansion e.g. The man is going to get the cat	8
Conjunctions – joining related clauses e.g. she fell down and break her glasses	10

Reliability: Expressive morphology and syntax transcription and scoring

Both therapist and student transcribed responses during the assessment sessions. Transcriptions were compared after the session and differences were resolved using audio and video recordings. Inter rater agreement on scoring of morphology (List 10) and sentence structure was calculated by comparison of rating assigned independently to 10 transcribed samples by two speech and language therapists and showed 100% agreement.

4. 6.vi. Data collection and scoring: sensory and structural

a) Oral structure and functioning

Oral structures and functioning were evaluated following a visual examination. The Fletcher diadochokinetic examination format was used to sample oral movement rate and range. Procedures were modified by providing visual cues to encourage rapid repetition. Standardised scoring procedures were not considered appropriate in view of variations in performance levels reported in young children (Williams & Stackhouse, 1996). Raw scores were noted in terms of number of repetitions achieved and time taken. Results were noted on the standard clinical form (appendix 4.8) and evaluated on a 3 point scale as follows:-

0 no significant findings

1 mild difficulties evident

2 severe difficulties evident

b) Auditory acuity

Pure tone hearing screening at 30 dB was carried out during detailed assessments sessions in studies 2 - 4. Response mode varied according to the age, attention levels and motivation of participants.

Table 4.34 Overview of studies, variables and procedures

Construct	Variable	Procedure	Groups (number)	Study	Analysis
Language base	Age equivalency score Language rating	Preschool Language Scale (PLS)	DS (75) TD (75) DS (40)	1 2 3	Descriptive Correlations (Spearmans) Comparison (Mann Whitney, Kruskal Wallis)
Phonological system	PCC/ CCR Phoneme inventory Process analysis Process strength System rating	Speech sample Naming test	DS (75) TD (75) DS (40)	1 2 3	Descriptive Correlations (Spearman's) Comparison Mann Whitney, Kruskal Wallis)
Intelligibility	Intelligibility level	Intelligibility rating scale	DS (75) TD (75) DS (40)	1 2 3	Descriptive Correlations (Spearman's) Comparison Mann Whitney, Kruskal Wallis)
Vocabulary	Receptive Age equivalency score Receptive /expressive Rating scales	British Picture Vocabulary Scale Renfrew Action Picture Test	DS (40)	2 3	Descriptive Correlations (Spearman's)
Grammar	Morphology: Receptive /expressive Rating scales Syntax: Receptive / expressive Rating scales	Test of Auditory Comprehension of Language Renfrew Action Picture Test	DS (40)	2 3	Descriptive Correlations (Spearman's) Comparison over time Wilcoxon

CHAPTER 5

RESULTS STUDY 1

5.1 Treatment of the data

Data obtained in the studies were explored using descriptive statistics and analysed using non-parametric statistical procedures. The use of non-parametric procedures was selected as appropriate for this study due to the nature of the measures and the characteristics of the population. The measures utilised both ordinal and interval rating scales. The groups selected were were small and sampling procedures were not guaranteed to result in a sample conforming to a normal distribution. This decision was supported by results of the Shapiro-Wilk test. This test is recommended for the evaluation of departures from normality in small to medium sized samples (Conover, 1999). The null hypothesis of the test is that the sample is taken from a normal distribution; this supposition is rejected when $p < 0.05$ for W. Chronological age, language age, and intelligibility for each group were calculated and the test was applied. Test statistics of $p = 0.0001$ for chronological age, $p = 0.0023$ for language age, and $p = 0.0011$ for intelligibility indicated that data from the Down Syndrome (DS) group did not show a normal distribution. The typically developing group, while showing a normal distribution for chronological age ($p = 0.0755$), was not normally distributed for language ($p=0.0188$) or intelligibility ($p < 0.0001$).

The following descriptive statistics and graphics were selected in order to capture different aspects of data distribution and explore developmental patterns and trends:

Means and standard deviations (SD) while not usually used when populations depart from the normal distribution were used in these studies in order to take account of all scores when identifying averages and dispersion and to facilitate the identification of outliers.

Median values are less susceptible to the influence of extreme observations and were used in this study along with the interquartile range to identify central values and distributions. Ranges and minimum / maximum values were also used in inter group comparisons.

The data were plotted to allow visual inspection of correlations (Scatter plots) and comparative data (Graphs, Histograms and Box plots based on the median, interquartile range and minimum/maximum values).

Relationships between speech measures and levels of development in general language were calculated using Spearman's rank correlation. The Mann Whitney test was used to analyse group differences.

Study 1

Data from speech measures on both groups were compared initially on a total group basis i.e. language age range 24 to 84 months. Further comparisons were made by dividing the groups into three subgroups by language level (Level 1 Language age range 24-42 months; Level 2 age range 43 -62 months; Level 3 age range 63-84 months) to explore developmental patterns. Participant characteristics are presented in appendix 5.1.

Descriptive statistics and graphics were used to identify and illustrate similarities and differences in developmental patterns.

Relationships between speech measures and levels of development in general language were calculated using Spearman's rank correlation.

The Mann Whitney test was used to analyse group differences. Intra and inter group comparisons were tested using the Kruskal-Wallis.

Study 2

Data obtained from participants in the smaller Down syndrome group were analysed to explore patterns of association between speech measures and developmental levels in components of receptive and expressive language. Participant characteristics are presented in appendix 6.1.

Descriptive statistics and graphics were used to identify patterns of associations between speech and language.

Spearman's rank correlation was used to calculate correlations between rated scores in intelligibility, consonants correct, number of processes, process strength, and developmental levels of vocabulary, morphology and syntax.

Study 3

Data obtained from repeated measures on the group who provided data for study 2 were explored to examine patterns of change in speech measures.

- The significance of changes was tested using the Wilcoxon signed ranks test.
- Associations between changes in speech status and changes in vocabulary, morphology and syntax were explored using descriptive statistics and tested using Spearman's correlation coefficients.

StatsDirect (2001) statistical software was used for all calculations

The remainder of this chapter presents descriptive summaries and statistical analysis of the data relevant to the questions asked in Study 1. The following questions were addressed: -

5.2. Do speech intelligibility levels reflect competency levels in general language skills?

5.3 Do speech intelligibility levels reflect phonological system development as measured by percentage of consonants correct?

5.4 Do speech intelligibility levels reflect phonological system development as measured by the number or type of active developmental processes?

5.5 Do speech intelligibility levels reflect phonological system development as measured by phoneme inventories?

5.6 Do the phonological systems of children and young adults with Down syndrome reflect developmental patterns observed in typically developing children?

5.7 Are there specific characteristics or clinical markers of speech impairment associated with Down syndrome?

5.2 Speech intelligibility and general language levels

Down Syndrome group data

The DS group showed a mean language score of 43.36 with a standard deviation of 14.49 (Median score 42: range 57). Intelligibility scores showed a mean 4.89 with a SD of 2.28. Data from the DS group indicated increases in intelligibility levels as language levels increased.

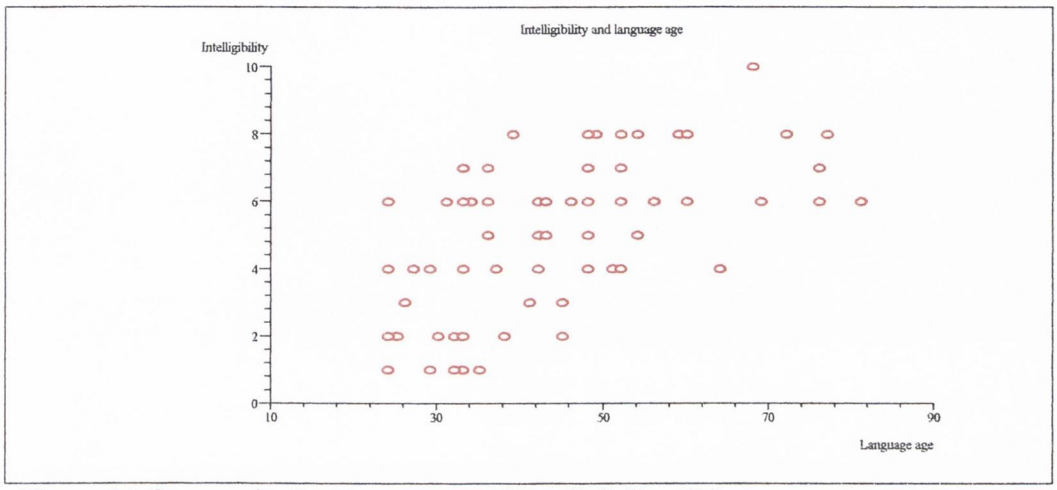


Figure 5.1 Scatter plot Language age and intelligibility: DS group

Figure 5.1 illustrates a strong positive association between intelligibility and language levels and reflects a wide spread in intelligibility scores across all points. Spearman's correlation gave a correlation coefficient of r = 0.68 which was statistically significant at p = < 0.0001 (N=75).

Typically developing group data

Analysis of intelligibility ratings for the TD group showed a mean score of 9.06 with a standard deviation of 1.31 (Median 10; Range 6). Mean language scores for this group were 43.93 with a standard deviation of 12.11 (Median 42; Range 60). Increases in intelligibility ratings were evident as language levels increased.

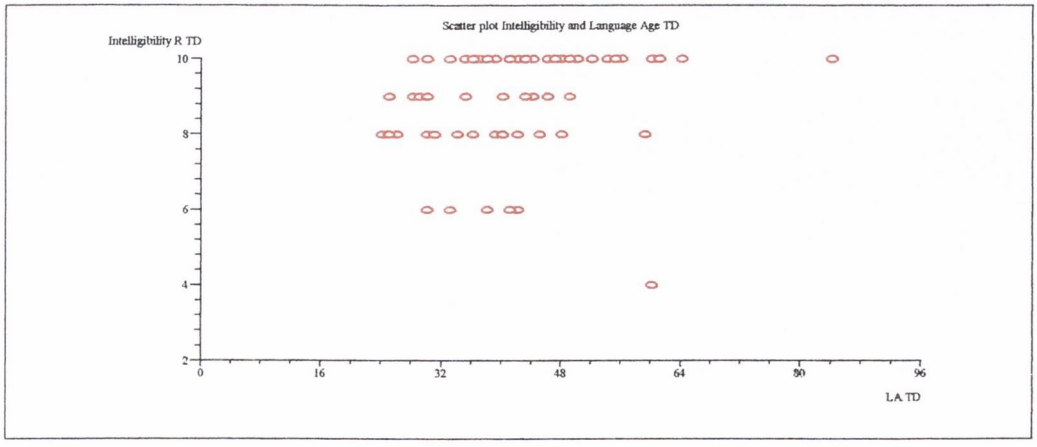


Figure 5.2 Scatter plot: Language age and intelligibility: TD group

The relationship between intelligibility and language age in the typically developing group was calculated and correlations indicated a moderate positive relationship statistically significant at P= 0.0002 (r = 0.414861; N=75). The concentration of scores between language age equivalents 24 and 42 months indicated that full intelligibility was achieved by the majority during this period.

Inter-group comparison: Intelligibility and general language levels

There were no significant differences between the groups on language levels but intelligibility measures indicated a statistically significant difference. The DS group showed a wider dispersion and lower intelligibility (Mean 4.89; SD 2.28) compared to the TD group (Mean 9.06; SD 1.31). Median scores in the DS group were half that of the TD group.

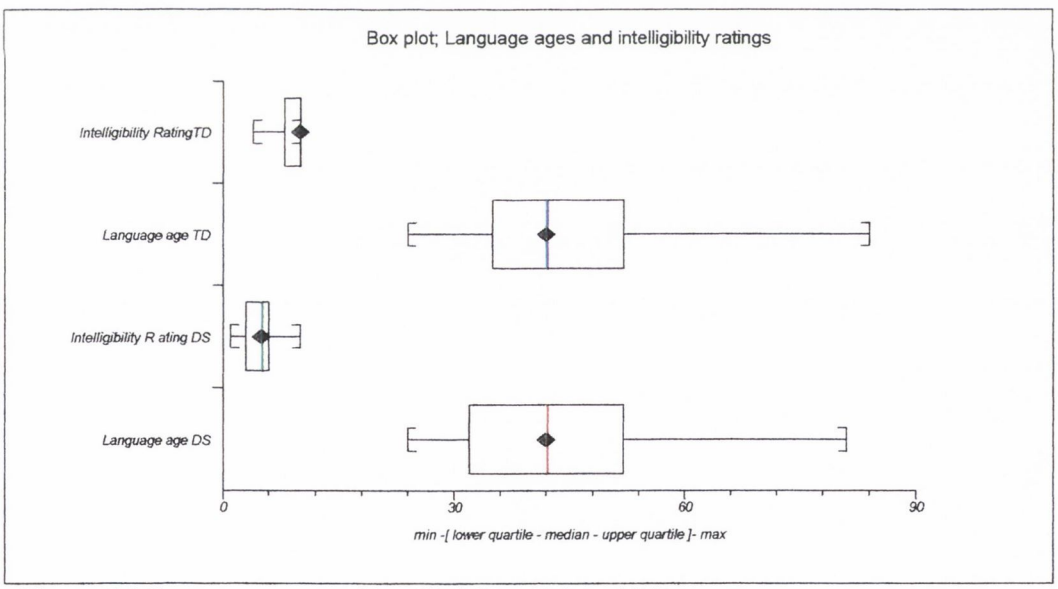


Figure 5.3 Language age and intelligibility: DS and TD groups

Differences in intelligibility scores between the group medians are evident in the box plot. Significance testing using the Mann-Whitney indicated a statistically significant difference at P < 0.0001 (U = - 9.53).

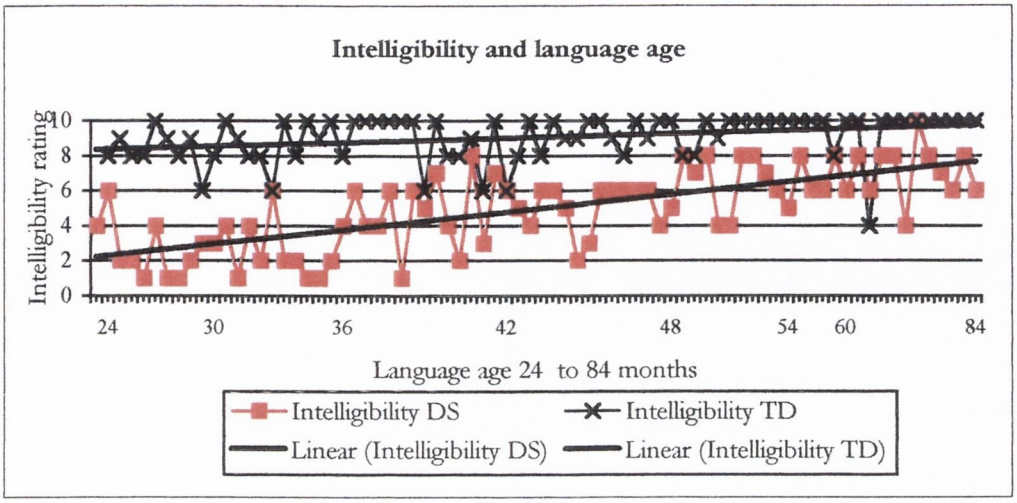


Figure 5.4 Intelligibility ratings and language age: Trends in DS and TD groups

Both groups showed increases in intelligibility as competency levels in general language skills developed but differences in base levels and in developmental patterns were evident. Data from the children and young adults with Down syndrome who participated in this study indicated that their intelligibility levels were lower at the base language age (24 months) and remained below the levels of the TD group across the language age range studied.

Developmental patterns

Analysis of the data by language levels subgroups indicated that speech intelligibility mean and median scores for both groups increased with language levels as summarized on the table 5.1

Table 5.1 Descriptive summary: Intelligibility DS and TD groups by language level.

Intelligibility	DS				TD				
Language level	Mean	SD	Med.	Range		Mean	SD	Med.	Range
1 n=38	3.58	2.02	4	7	n=38	8.66	1.34	9	4
2 n= 29	6.07	1.62.	6	6	n=29	9.34	1.26	10	6
3 n =8	6.87	8.11	6	6.5	n =8	10	0	10	0

Mean and median scores for the DS group were approximately half those of the TD group at Level 1 (Language age range 24-42) and remained lower at the later levels as illustrated by figure 5.5.

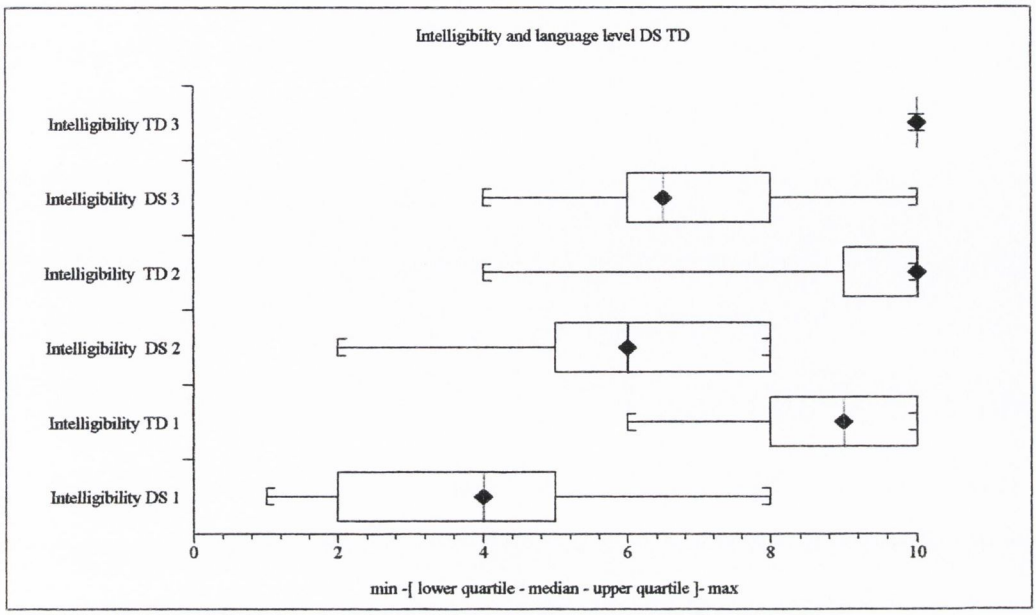


Figure 5.5 Intelligibility across DS and TD language level subgroups

The statistical significance of differences between and within the groups was tested using the Kruskal –Wallis.

Intra group comparisons in the DS group indicated statistically significant differences between intelligibility at level 1 and 2 (H= 6.39; P < 0.0001) and between level 1 and 3 (H = 4.80; p < 0.009). Differences at level 2 to 3 were not statistically significant (H =1.46; P =0.9059) in this group.

Comparisons between levels in the TD group indicated limited significance between levels 1 and 3(1-3 H = 4.22; P = 0.0337: 1 –2 H = 3.55; P = 0. 0.1193: 2-3 H = 2.67; P = 0.4067).

Inter group comparisons were significant at all levels as summarised on table 5.2.

Table 5.2. Intelligibility: Inter group comparisons: Kruskal –Wallis

Intelligibility (q= 4.03)	TD 1 n=38	P		TD 2 n= 29	P		TD3 n=8	P	
DS 1 n=38	10.17	≤0.0001	***	9.70	<0.0001	***	6.30	≤0.0001	***
DS 2 n= 29				8.56	≤0.0001	***	6.20	≤0.0002	***
DS 3 n =8							4.60	≤0.0144	*

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Speech intelligibility and general language levels: Summary

Speech intelligibility levels increased with competency levels in general language skills in both groups but results indicated that the participants in the DS group differed from the TD group in the rate of development of intelligible speech relative to general language skills. Intelligibility scores in the DS group were significantly lower than in the TD group at the base language age of 24 months and remained lower over the developmental language period studied. Speech intelligibility in the DS group studied showed a protracted period of development relative to language skills.

5.3 Speech intelligibility and phonological system development

Data from measures of speech intelligibility were compared to measures of phonological system development to identify patterns of association between intelligibility and percentage of consonants correct, number of processes, process strength and type.

Speech intelligibility levels and percentage of consonants correct

Down Syndrome group data

The DS group showed percentage of consonants correct scores (PCC) ranging from 3% to 93%. The group median score was 53 (Mean 51.66; SD 25.03). The relationship between intelligibility and percentage of consonants correct is illustrated in figure 5.6.

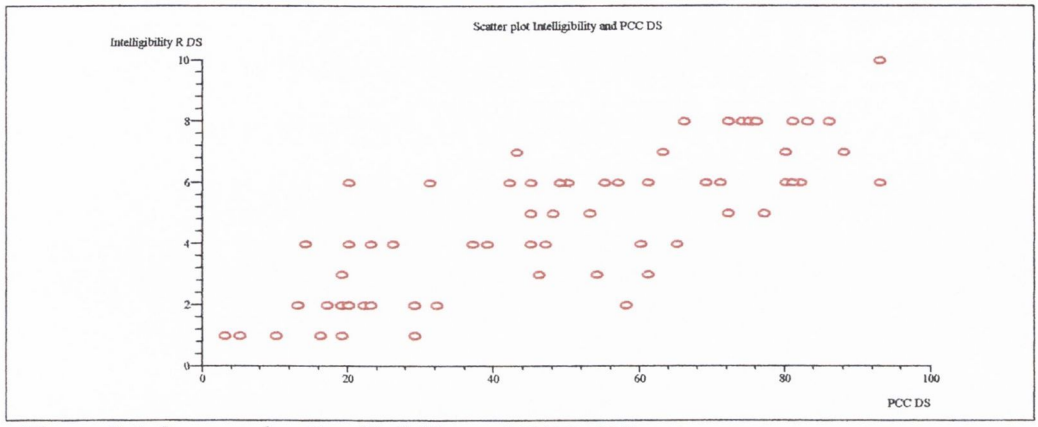


Figure 5.6: Scatter plot: Intelligibility and PCC: DS group

Spearman's correlation indicated a strong positive relationship between intelligibility and percentage of consonants correct which was statistically significant at $p < 0.0001$ ($r = 0.80$; $N = 75$).

Typically developing group data

Percentage of consonant correct scores from the TD group indicated that the majority were using all the singleton consonants required by the phonological system. Scores ranged from 73 to 100 with a median score of 100 (Mean 95; SD 6.95). Intelligibility levels increased with increases in percentage of consonants correct as illustrated by Figure 5.7.

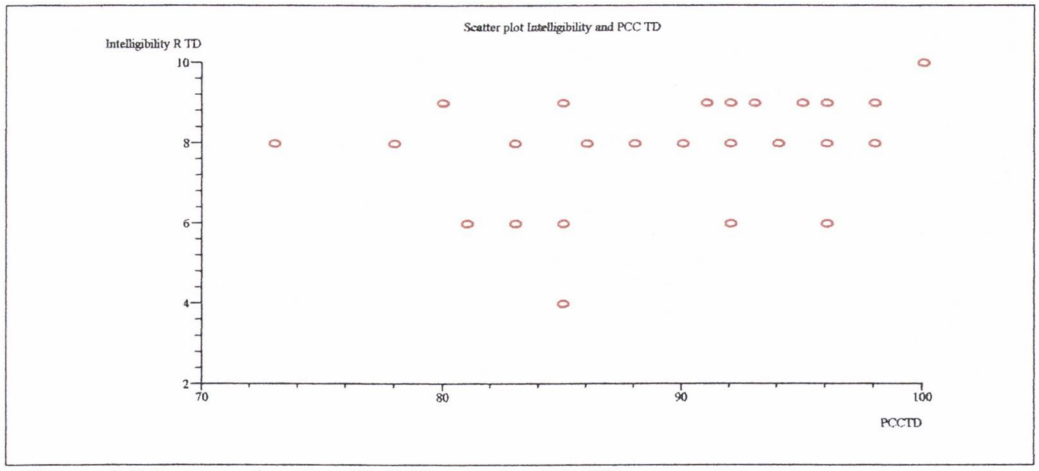


Figure 5.7 Scatter plot: Intelligibility and PCC: TD group

The strong positive association between PCC and intelligibility in this group was found to be statistically significant with r = 0.93; p=< 0.0001, N=75.

Inter-group comparison: Intelligibility and PCC levels

Percentage of consonants correct scores from both groups indicated differences in mean and median scores as well as in range and spread as presented in table 5.3.

Table 5.3: Descriptive statistics: PCC: DS and TD groups

PCC	Mean	SD	Median	Range
DS (N=75)	51.66	25.03	53	90
TD (N=75)	95	6.95	100	27

Median differences are illustrated by the box plot (figure 5.8).

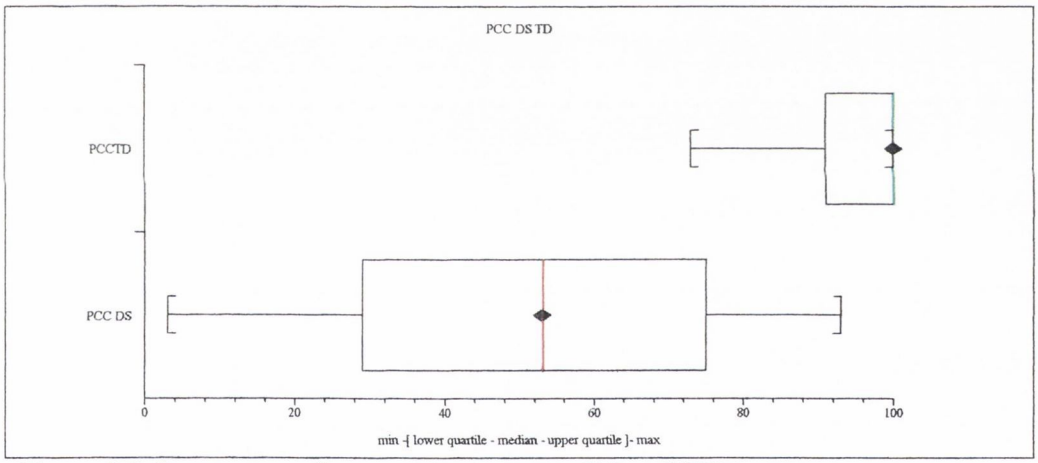


Figure 5.8: Percentage of consonants correct: DS and TD groups

Differences between the groups on PCC scores were found to be statistically significant at p< 0.0001 (U = 10.19) when tested with the Mann –Whitney.

Percentage of consonants correct scores showed a significant relationship with intelligibility in both groups (p= <0.0001). Differences in degree were evident with the DS group showed a weaker correlation with r = .80 compared to r =. 93 in the TD group.

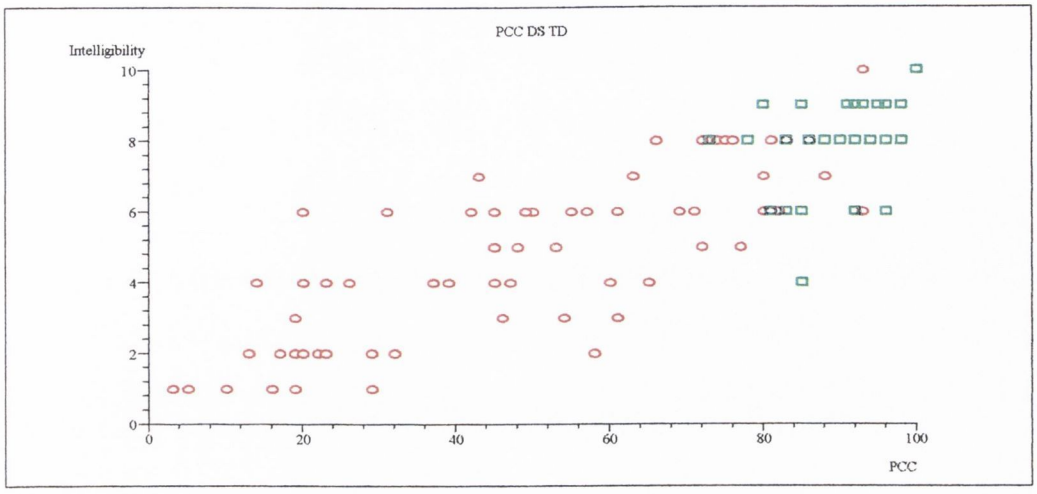


Figure 5.9 Intelligibility and PCC: DS and TD groups

Developmental patterns

Inter-group comparison indicated differences between the DS and TD groups at all language levels.

Table 5.4 Descriptive Summary: Percentage of consonants correct (PCC)

PCC	DS					TD			
Language level	Mean	SD	Med.	Range		Mean	SD	Med.	Range
1 n=38	38.68	23.64	31.5	90	n=38	92.45	7.69	92.5	27
2n=29	63.14	18.03	66	74	n=29	96.96	4.45	100	20
3 n =8	74.87	13.37	85	4	n=8	100	0	100	0

PCC scores increased with language levels in both groups but the DS groups showed lower scores and greater variability than the TD groups at all levels.

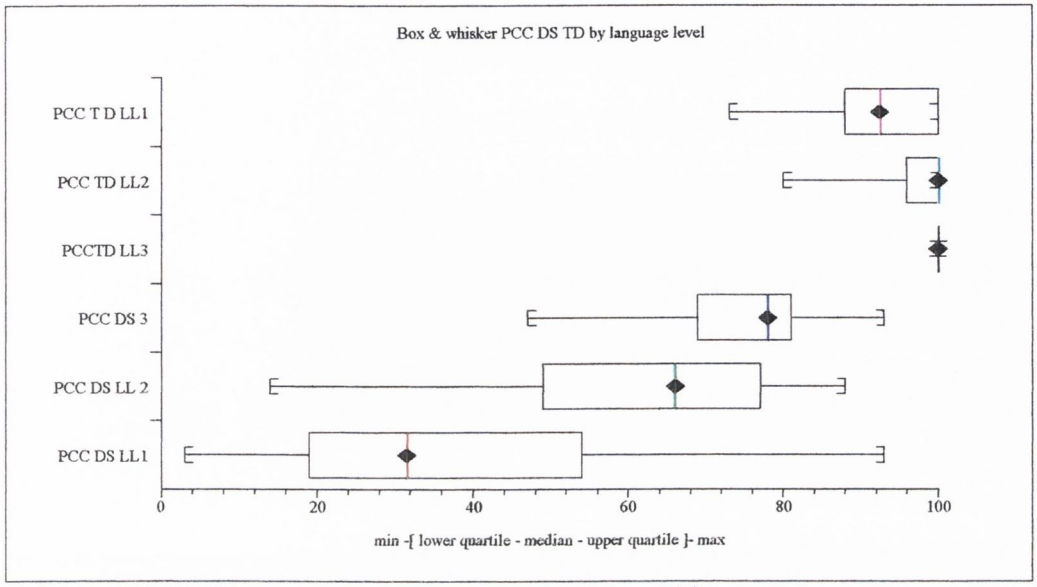


Figure 5.10 PCC across three language levels: DS and TD groups

Intra and inter group comparisons on PCC were tested for significance using the Kruskal –Wallis. Comparisons of DS data at the three language levels indicated statistically significant differences between level 1 and 2 (H= 5.70;P = 0.0008) and to a lesser extent between level 1 and 3 (H= 4.96; P = 0.006). There were no statistically significant differences between levels 2 and 3 (H 2.12; P = 0.667).

The TD group data showed no statistically significant differences between levels 1 and 2, or between 2 and 3 (H = 3.71; p= 0.0914; H=2.67; p= 0.4099). Comparison between PCC at level 1 and 3 indicated significance at p= 0.0375 (H = 4.17).

Comparisons between the groups at the different language levels indicated significance at all levels as summarized on table 5.5.

Table 5.5 PCC: Inter group comparisons: Kruskal –Wallis (q = 4.03)

PCC	TD 1 n=38	p		TD 2 n= 29	p		TD 3 n =8	p	
DS 1 n=38	10.21	0.0001	***	9.83	< 0.0001	***	6.25	0.0001	***
DS 2 n= 29				9.18	< 0.0001	***	6.08	0.0002	***
DS 3 n = 8							5.08	0.0044	**

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Correlations between intelligibility and PCC showed differences in developmental pattern between the two groups as indicated by comparison of correlation results summarised on table 5.6.

Table 5.6 Correlations between intelligibility and PCC

PCC	DS				TD				
Language level	r		p			r		p	
1 n=38	0.82	V strong	<0.0001	***	n=38	0.79	Strong	<0.0001	***
2 n= 29	0.57	Moderate	0.0014	**	n=29	0.97	V.Strong	<0.0001	***
3 n =8	0.45	Moderate	0.2431	NS	n =8	1		<0.0001	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Percentage of consonants correct showed a steady increase as language levels increased in the TD group. The relationship weakened in the DS group.

Summary: Speech intelligibility and percentage of consonants correct

Percentage of consonants correct scores increased with language levels in both groups but the DS groups showed lower scores and greater variability than the TD groups at all levels. Correlations between percentage of consonants correct and speech intelligibility were stronger in the TD group. Comparison of correlations across the language levels indicated an increasingly strong relationship in the TD groups while the opposite was found in the DS groups.

5.4. Speech intelligibility levels and active developmental processes

Number of processes

Down Syndrome group data: number of processes

The number of processes evident in data from the DS group participants ranged from 3 to 15 with a median score of 7 and a mean of 7.83 (SD 2.86). A weak pattern of association with intelligibility is illustrated by figure 5.11.

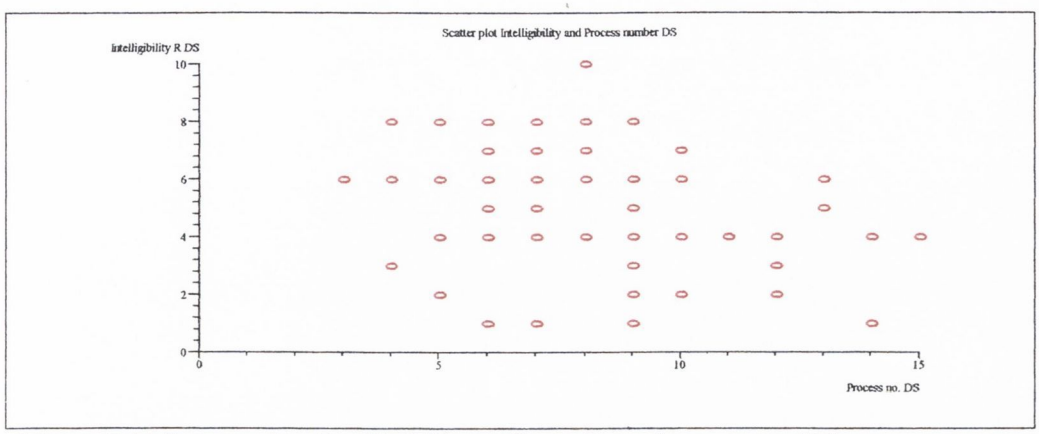


Figure 5.11 Scatter plot: Intelligibility and number of processes: DS group

Spearman's correlation between process number and intelligibility gave a correlation coefficient of r = -0.36 which was statistically significant at p= 0.0017 (N=75).

Typically developing group data: number of processes

Data analysis indicated that majority of the samples in this group showed no active processes (Median 0; Range 4: Mean 1.05; SD 1.34). Active processes were identified in 32 individual speech samples with eight showing one active process, nine showing two, and twelve showing three. Three samples showed four active processes. A low process number score was associated with increasing intelligibility in this group as illustrated by Figure 5.12.

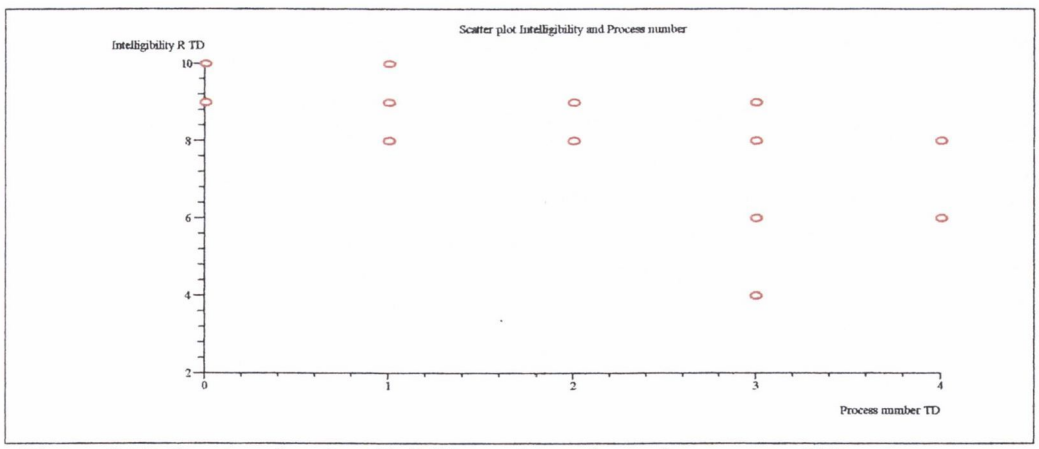


Figure 5.12: Scatter plot: Intelligibility and number of processes: TD group

There was a strong negative correlation between number of processes and intelligibility, statistically significant at $P<0.0001$ ($r = -0.92$; $N=75$).

Inter-group comparison: number of processes

The groups showed a significant difference on scores for number of processes ($U = 10.56$; $p< 0.0001$). The DS group showed a higher number of processes and a wider range than the TD group as shown in figure 5.13.

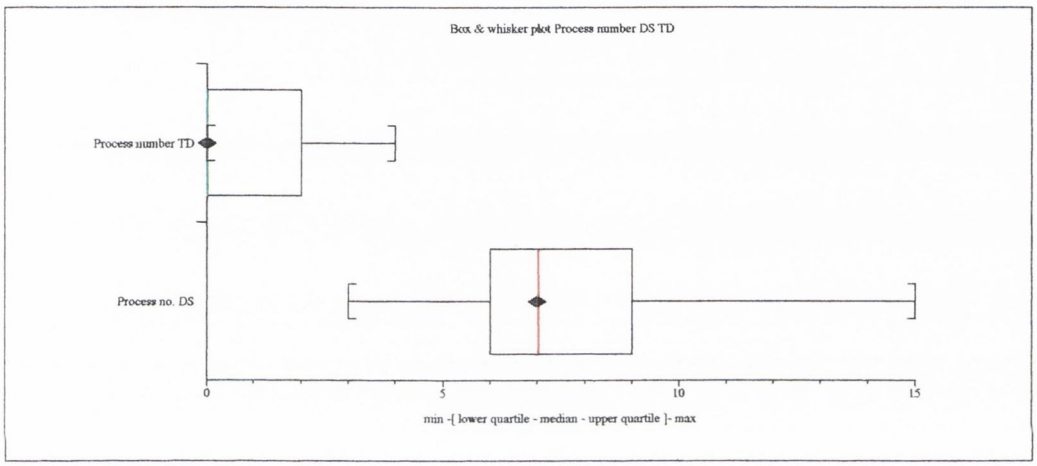


Figure 5.13 Number of processes: DS and TD groups

All participants in the DS group showed at least three unsuppressed processes while 57 % of participants in the TD group had suppressed all processes (Figure 5.14).

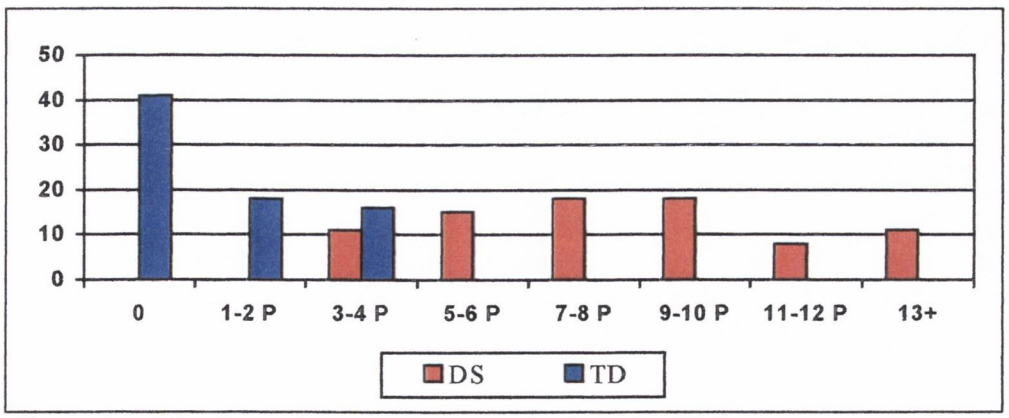


Figure 5.14 Number of processes frequencies in DS and TD groups

Seventy three percent of the participants (55) from the DS group showed over seven active processes while none of the participants in the TD group exceeded four.

Correlations between the number of processes and intelligibility were negative for both groups but the strength of the association varied with the DS group showing a weak relationship ($r = -0.36$; $p = 0.0017$; $N=75$) and the TD group a strong relationship with $r= -.92$ ($p = 0.0001$; $N =75$).

Developmental patterns: number of processes

The number of processes present decreased as language levels increased in both groups. Differences between the groups were evident in mean and median scores at all language levels.

Table 5.7 Descriptive summary: Number of processes

Number of processes	DS				TD				
Language level	Mean	SD	Med.	Range		Mean	SD	Med.	Range
1 n=38	8.52	3.09	8.5	14	n=38	1.55	1.43	1.5	4
2 n= 29	6	2.37	5	10	n=29	0.65	1.14	0	4
3 n =8	4.25	1.49	4	4	n =8	0.120	.35	0	1

The DS samples showed a greater number of active processes at all language levels as illustrated in figure 5.15.

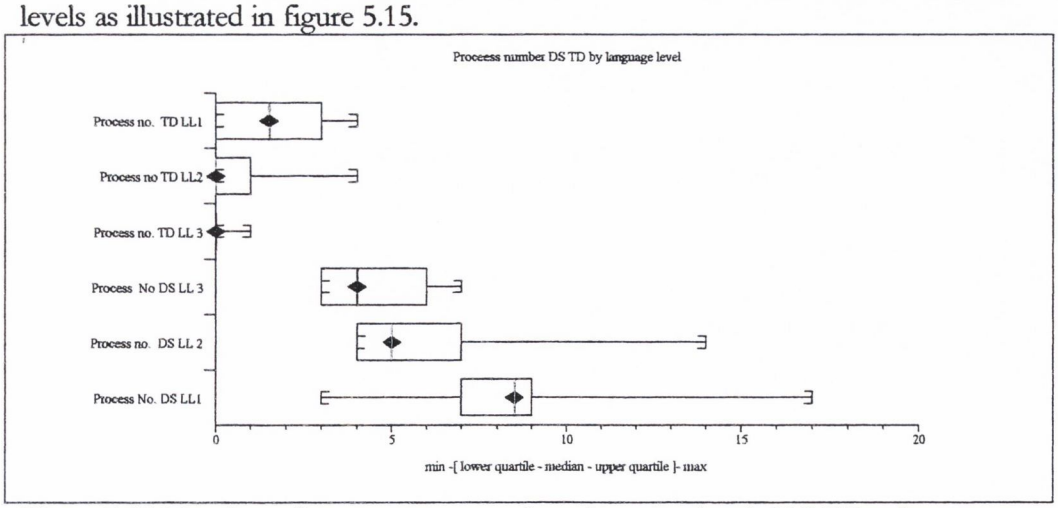


Figure 5.15 Number of processes across three language levels DS TD subgroups

Differences between the DS subgroups were significant at $p<0.01$ between all levels (levels 1-2 H= -5.13; p= 0.0039; 2-3 H=-5.16; p= 0.0036; 1–3 H=-5.16; p= 0.0036). The TD groups did not show any statistically significant changes with language levels (1-2 H= -3.84; p= 0.072: 2-3 H=-3.76; p= 0.0841: 1-3 H= -3.76; p = 0.857). Inter-group comparison indicated significant differences at all levels (table 5.8).

Table 5.8: Number of processes: Inter group comparisons

Process numbe Kruskal–Wallis q = 4.03	TD 1 n=38	P		TD 2 n=29	P		TD 3 n=8	P	
DS 1 n=38	-10.52	≤0.0001	***	-9.97	≤0.0001	***	-9.97	≤0.0001	***
DS 2 n=29				-9.37	≤0.0001	***	-6.17	≤0.0002	**
DS 3 n=8							-4.99	≤0.0055	*

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

The number of processes present did not show any statistically significant correlations with intelligibility in the DS subgroups. The TD groups showed statistically significant negative correlations at all levels.

Table 5.9 Correlations between intelligibility and number of processes

No. of processes	DS			TD				
	r	p			r	Negative	p	
1 n=38	0.06	0.7321	NS	n=38	-0.87	Strong	<0.0001	***
2 n= 29	0.007	0.9664	NS	n=29	-0.93	V strong	<0.0001	***
3 n =8	-0.37	0.3599	NS	n =8	1		<0.0001	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Summary: Speech intelligibility and number of processes

The number of active developmental processes was significantly higher in the participants from the group with Down syndrome compared to those in the typically developing group. The majority of the DS group showed at least seven active processes while the majority in the TD group showed none. The number of processes present correlated negatively with intelligibility in the TD group but

did not show any statistically significant correlations with intelligibility in the DS subgroups.

Process strength

Down Syndrome group data: process strength

Measures of process strength, reflecting the number of phonemes influenced by each process, showed a mean score of 13.88 (SD 5.98) in the DS group. Scores ranged from 3 to 21 with a median score of 14. Higher scores in process strength were associated with lower scores in intelligibility as is illustrated by figure 5.16.

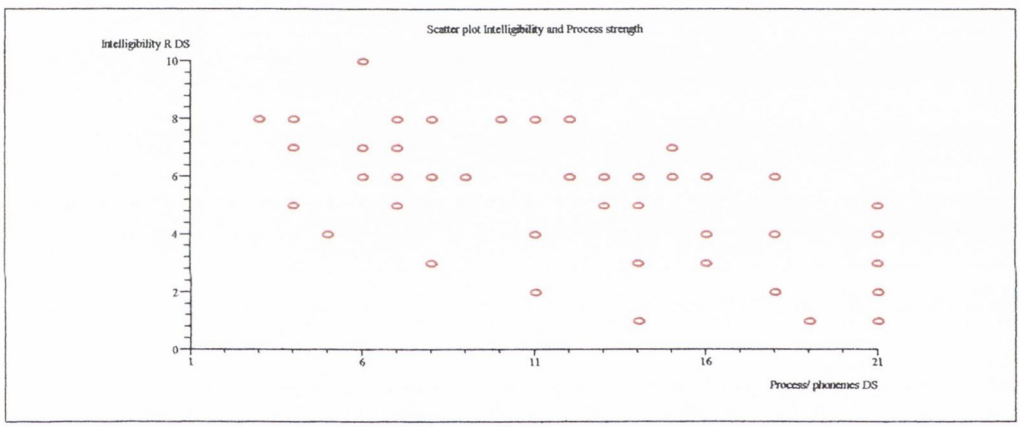


Figure 5.16: Scatter plot: Intelligibility and process strength DS group

A strong negative association was evident between process strength and intelligibility. This was tested using Spearman's correlation coefficient and was found to be statistically significant with $r = -0.72$: $p < 0.0001$: $N = 75$.

Typically developing group data: process strength

Processes in the TD data showed low strength with a mean score of 1.70 and a standard deviation of 2.23. Low process strength was associated with higher intelligibility scores in the group as illustrated by figure 5.17.

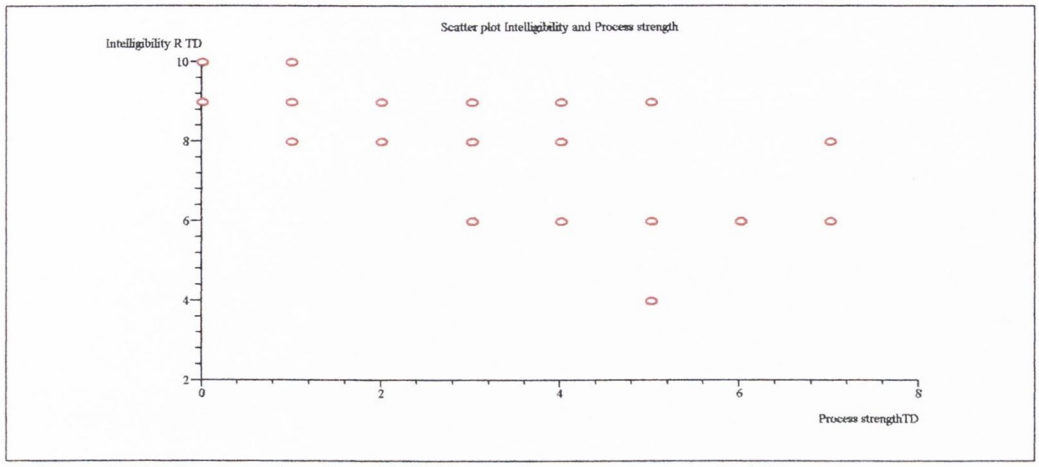


Figure 5.17. Scatter plot: Intelligibility and process strength: TD group

Spearman's correlation indicated a strong negative association with r = -0.91, significant at p=< 0.0001 (N=75).

Inter-group comparison: process strength

Median scores and ranges indicated differences in the number of phonemes influenced by processes in the groups, as illustrated by figure 5.18. The number of phonemes influenced by each process was greater for participants in the DS group with a median of 14 (mean 13.88) compared to a median of 0 (mean 1.71) in the TD group.

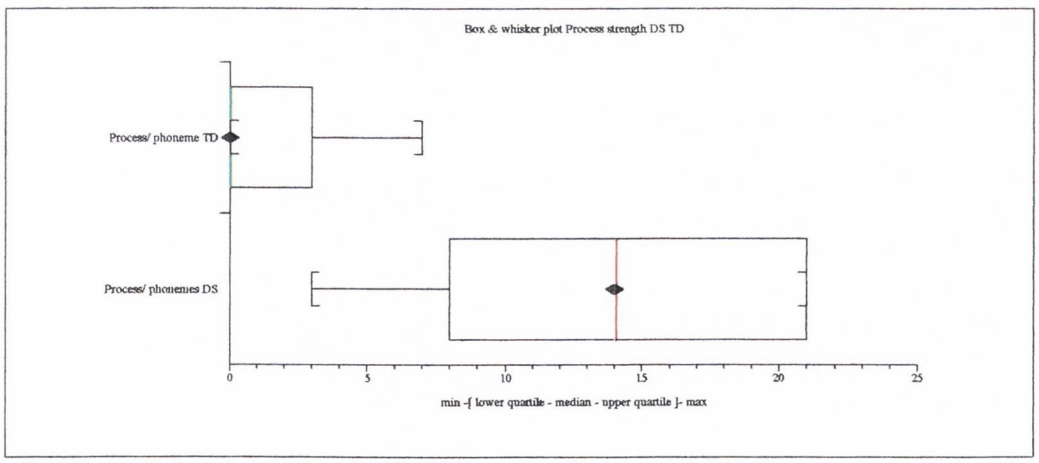


Figure 5.18: Process strength: DS TD groups

The Mann Whitney tested differences between the groups as statistically significant at p= < 0.0001 (U= -10.25).

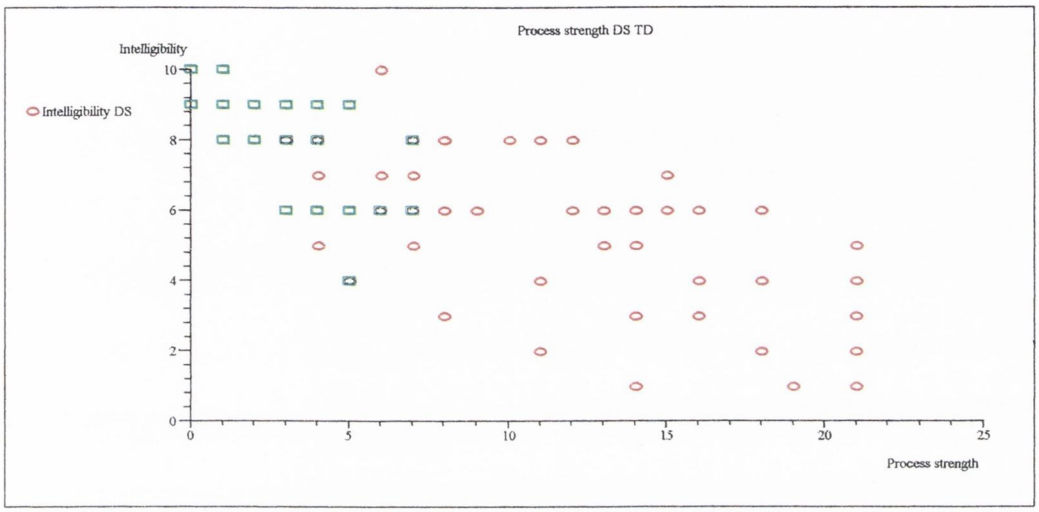


Figure 5.19: Intelligibility and process strength: DS and TD groups

Process strength correlated negatively with intelligibility in both groups with correlations of r= - 0.72 (p< 0.0001; N=75) in the DS group and r = -0.91 (p < 0.0001; N=75) in the TD group (figure 5.19).

Developmental patterns: process strength

Process strength decreased as language levels increased in both the DS and TD groups. Differences within and between groups are summarised in table 5.10.

Table 5.10 Descriptive statistics: Process strength

Process strength	DS				TD				
Language level	Mean	SD	Med	Range		Mean	SD	Med	Range
1 n=38	17.16	5.21	21	17	n=38	2.53	2.41	3	7
2 n= 29	11.07	4.34	11	17	n=29	1.03	1.86	0	7
3 n =8	8.5	5.88	6.5	18	n =8	.25	.46	0	1

Differences were evident in the mean number of phonemes influenced by developmental processes in both groups at all levels. Mean process strength in the

DS group was seven times greater than in the TD group as illustrated by figure 5.20.

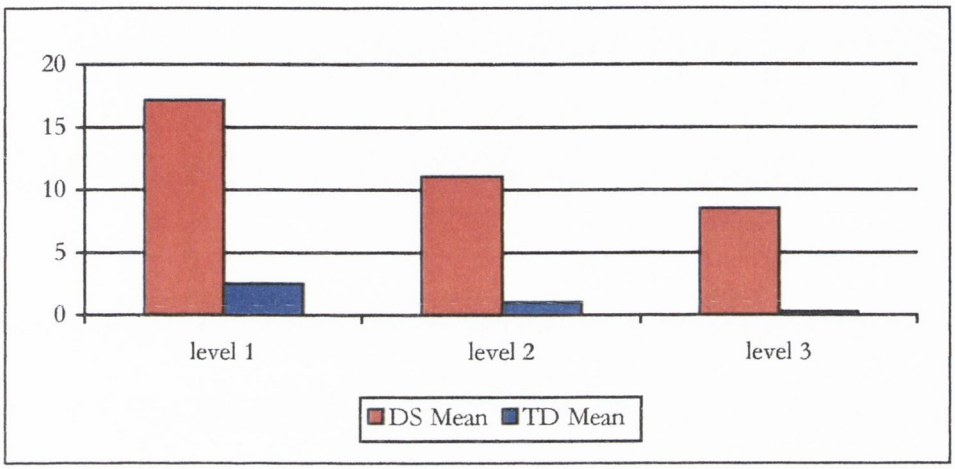


Figure 5.20: Comparison of mean scores for process strength.

Differences were also evident in median scores and in spread across the three language levels in the DS and TD groups (figure 5.21).

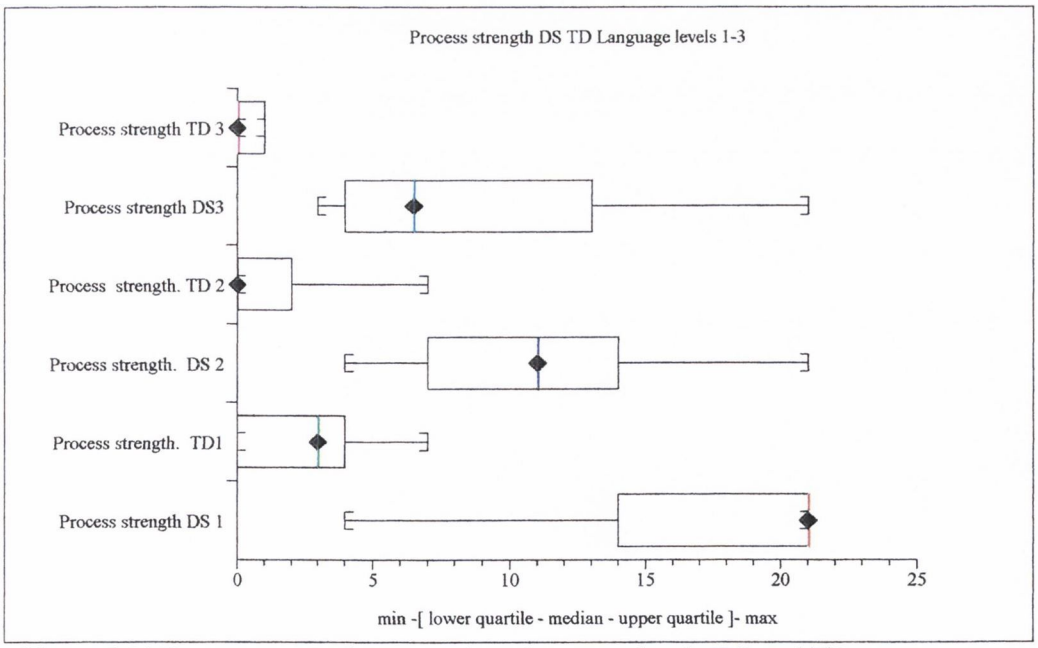


Figure 5.21 Process strength across three language levels DS and TD

Median scores in both groups decreased with increasing language levels. The TD median reaching 0 at level 2 while the DS group did not reach this by level 3. The DS groups showed a wider range at all levels.

Comparisons within each group at the three language levels were tested for significance using the Kruskal –Wallis. The DS subgroups showed statistically significant difference between at language levels 1 and 2 with P = ≤0.0001 (H= -6.25). Differences were found between and 1 and 3 in the DS data. No statistically significant differences were found between the other levels (2-3; H=-2.44; p = 0.517: 1-3 H= -4.61; p= 0.0141). Comparisons across the TD subgroups found no significant differences (1-2 H=-3.88; p = 0.0685: 2-3 H= -0.97; p= 0.9836: 1-3 H=-3.44; p = 0.1462).

There were significant differences between the groups at all language levels as summarized on table 5.11.

Table 5.11: Process strength: Inter group comparisons Kruskal –Wallis (q = 4.03)

Process Strength	TD 1 n=38	P		TD 2 n=29	P		TD 3 n=8	P	
DS 1 n=38	-10.50	<0.0001	***	-10.05	0.0001	***	-6.25	<0.0001	***
DS 2 n=29				-9.23	<0.0001	***	-6.08	0.0002	***
DS 3 n=8							-4.89	0.0072	**

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Process strength showed strong correlations with intelligibility across all levels in the TD group but statistically significant correlations were found only at level 1 for the DS group.

Table 5.12 Correlations: Intelligibility and process strength

Process strength	DS				TD				
Language level	Rho	All neg.	p		LL	Rho	All neg.	P	
1 n=38	-0.60	Strong	<0.0001	***	n=38	-0.86	V. Strong	<0.0001	***
2 n= 29	- 0.20	Weak	0.303	ns	n=29	- 0.92	V. Strong	<0.0001	***
3 n =8	-0.59	Moderate	0.1323	ns	n =8	1	V. Strong	<0.0001	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Summary Speech intelligibility and process strength

Active processes in the data from the participants with Down syndrome were stronger than those in the typically developing group. The number of phonemes influenced by each process ranged 3 to 21 in the DS data compared with 1 to 7 in the TD group. Process strength decreased in both groups as language levels increased. Intelligibility correlated with process strength across all levels in the TD group but statistically significant correlations were found only at level 1 for the DS group.

Process type

The data were analysed to identify the number of each major class of process present and to explore associations between process type and intelligibility.

Down syndrome group data: process type

Structural processes were present in 96% of samples and place processes in 79%. Manner and assimilation processes occurred with less frequency in the data with manner evident in 11% and assimilation in 8%.

Structural processes

The number of structural processes present ranged from 0 to 8 with a median of 4 (Mean 3.76: SD 1.98). High scores on structural processes were associated with low intelligibility scores (Figure 5.22).

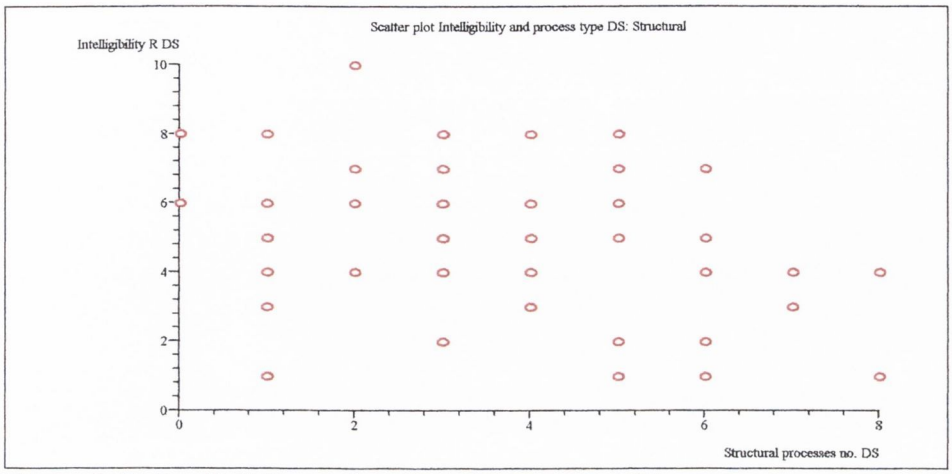


Figure 5.22. Intelligibility and structural processes: DS group

Correlation analysis indicated a moderate negative association between structural processes and intelligibility which tested as significant at $p < 0.0001$ ($r = -0.47$: $N = 75$).

Place processes

Place processes showed a range of 1-3 with a median score of 1 (SD 0.85: Mean 0.95). No significant association was found between place processes and intelligibility ($r = -0.08$; $p = 0.5004$; $N = 75$)

Manner processes

Manner processes ranged from 0 to 7 with a median of 3 (SD 1.68: Mean 3.03). The number of manner processes present did not show any clear pattern of association with intelligibility levels ($r = -0.09$: $P = 0.4425$: $N = 75$).

Assimilation processes

The small number of assimilation processes showed a non-significant, negative correlation with intelligibility ($r = -0.26$; $p = 0.0216$; $N = 75$). Assimilation processes occurred in the samples of five participants only – three had one active process, while two had two processes.

Typically developing group data: process type

Structural processes

Consonant cluster reduction was the only structural process evident in the group data. Mean score for structural processes was .17 (SD .38; Range 1; Median 0).

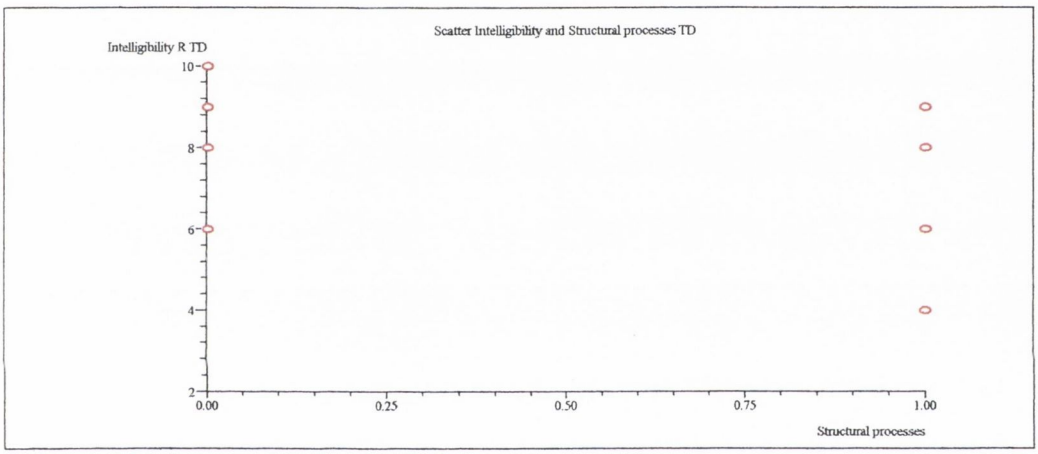


Figure 5.23 Scatter plot: Intelligibility and structural process

TD Structural processes showed a moderate negative association with intelligibility $r = -0.57$ ($p < 0.0001$; $N = 75$).

Place processes

Fronting of place was evident in 11% of the speech samples from the TD group. The mean score for place processes was .21 with standard deviation of .42; the range was 1 and median 0.

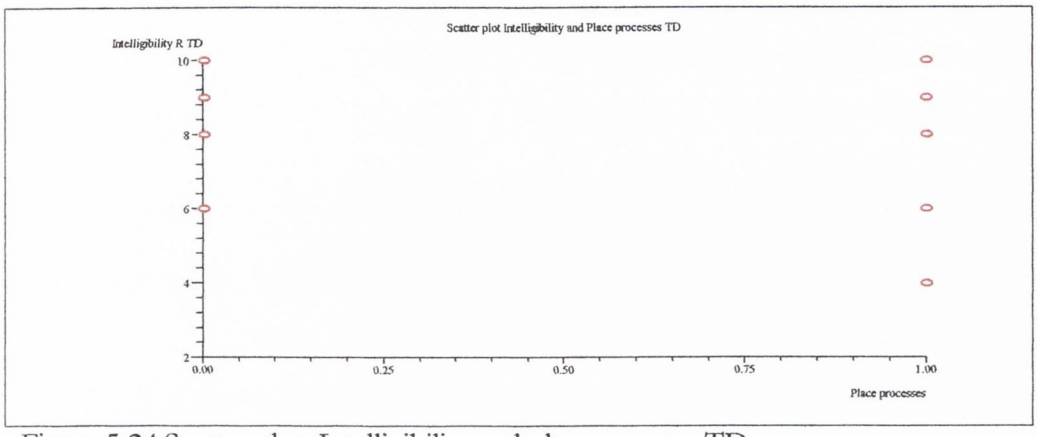


Figure 5.24 Scatter plot: Intelligibility and place process: TD group

Place processes showed a moderate negative correlation with intelligibility in this group ($r = -.56$; $P < 0.0001$; $N = 75$).

Manner processes

The following manner processes were identified in the data from the TD group, Stopping (12%), Gliding (28%), De-affrication (8%) and Voicing (3%). The number of processes ranged from 0-3 with a median of 0 and a mean of .65 (SD .89).

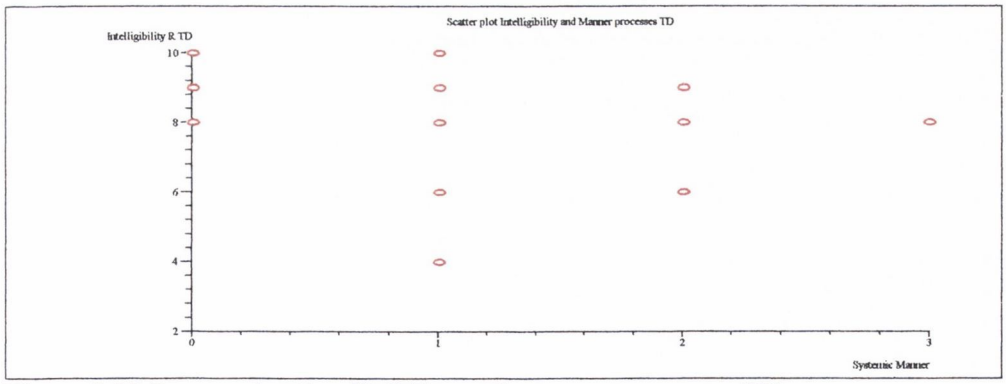


Figure 5.25 Scatter plot: Intelligibility and manner processes: TD

The high number of manner processes showed a strong pattern of association with reduced intelligibility scores. Spearman's correlation tested statistical significance at $p = 0.0001$ ($r = -81$, $N=75$).

Assimilation processes

There were no assimilatory processes identified in the TD data.

Inter-group comparison: Process type

Process type DS and TD groups

Descriptive statistics indicated differences in range median and mean scores for all process types as illustrated by figure 5.26.

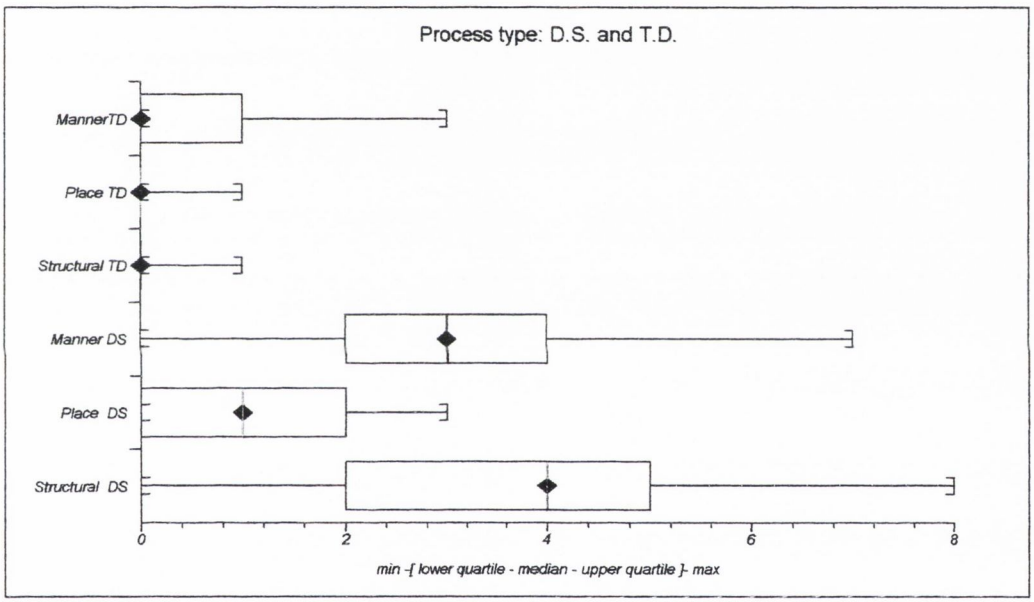


Figure 5.26. Structural, place, and manner processes: DS TD groups

All process types occurred with greater frequency in the DS group. Structural processes, which showed a stronger pattern of association with intelligibility than those of place and manner, were more prevalent in this group. Differences in structural processes between the groups tested as statistically significant at $p< 0.0001$ ($U=10.30$). Comparison of place and manner scores between the groups also tested as statistically significant on the Mann Whitney with $p= <0.0001$ (Place $U = 5.88$: Manner $U = 8.26$). Assimilation processes did not occur to any statistically significant extent in the data from the DS group and none was identified in the TD group.

Intelligibility and process type

All process types showed negative correlations with intelligibility in both groups. Structural processes showed a moderate negative correlation, significant at $p< 0.0001$, in both groups. (DS $r = - 0.47$; N=75 and TD $r =- 0.57$; N=75).

Place and manner processes did not show any significant relationship with intelligibility in the DS data (Place $r = -0.08$; $p= 0.5004$; N=75: Manner -0.09; $p=0.4425$; N=75). The TD group data indicated a statistically significant association at $p= <0.0001$ (Place $r= -0.55$: Manner $r = -0.81$ N=75).

Types of process: occurrence rate

Analysis of the prevalence of specific processes in the groups indicated a wider range of processes of all types in the DS group data as summarised in tables 5.13 - 16.

Table 5.13 Structural processes by percentage occurrence rate

Structural processes: Syllable structure		**%DS group**	**%TD group**
USD	Unstressed/Weak syllable deletion	57	0
RM	Reduction to monosyllables	25	0
SR	Reduplication	20	0
FCD	Final consonant deletion	71	0
ICD	Initial consonant deletion	33	0
CCD	Cluster deletion	29	0
CCR	Cluster reduction	79	12
E	Epenthesis	0	0
RUS	Reduction of unstressed syllable	5	0
USS	Replacement of unstressed syllable by single sound/ syllable	3	0
MS	Reordering of segments	4	0

Participants from the Down Syndrome group showed a range of unsuppressed processes across all levels of syllable structure. Deletion processes to reduce syllable structure were prevalent. Reduction at word level was also evident in the DS samples with deletion, reduction or replacement of unstressed syllables. Data from the TD group showed reduction of complex syllable onset only.

Table 5.14 Place processes by percentage occurrence rate

Systemic simplification: Place processes		**% DS group**	**% TD group**
F	Fronting	43	11
B	Backing	11	0
B+	Backing +	7	0
GR	Glottal replacement	0	0
SSP	Systemic sound preference / Favourite sounds.	16	0

Participants from both groups showed fronting of place of articulation as the predominant place process, but this occurred to a greater extent in the DS group. Backing and systemic sound preference was evident only in the DS data.

Manner processes

Table 5.15 Manner processes by percentage occurrence rate

Systemic simplification: Manner processes		**% DS group**	**% TD group**
S	Stopping	27	12
AFF	Affrication	0	0
GL	Gliding liquids	61	28
GO	Gliding other than liquids.	32	0
DAF	De-affrication	56	8
N	Nasalisation	12	0
DN	Denasalization	17	0
L	Lateralization	17	0
V	Voicing	45	3

Participants from the DS group showed a wider range of manner processes then was found in the TD group. Both groups showed stopping, gliding of liquids, de-affrication and voicing but these occurred with greater frequency in the DS group. The DS group also showed nasalisation, denasalisation and lateralisation not evident in the TD data.

Assimilation processes

Table 5.16 Assimilation processes by percentage occurrence rate

Assimilation processes		**% DS group**	**% TD group**
VA	Velar assimilation	1.3	0
LA	Labial assimilation	1.3	0
NA	Nasal assimilation	6.6	0
AA	Alveolar assimilation	6.6	0
LiA	Liquid assimilation	6.6	0
Vo.P	Vowel place assimilation	0	0
PV	Prevocalic voicing	0	0
DV	Final devoicing	0	0

Assimilation processes were present in a limited number of samples in the DS group but did not occur in the TD samples.

Developmental patterns: process type

Structural processes

Structural processes were more evident in the DS data at all levels but did not feature to any significant extent in the TD data. Table 5.17 summarises descriptive data on the groups.

Table 5.17 Descriptive Summary: structural processes

Structural	DS				TD				
Language level	Mean	SD	Med.	Range		Mean	SD	Med.	Range
1 n=38	4.39	1.82	5	8	n=38	.23	.43	0	1
2 n=29	2.83	1.46	3	5	n=29	.13	.35	0	1
3 n=8	2.12	1.55	2	6	n =8	0	0	0	0

Structural processes decreased in both groups over the language levels and were absent from TD data by level 3.

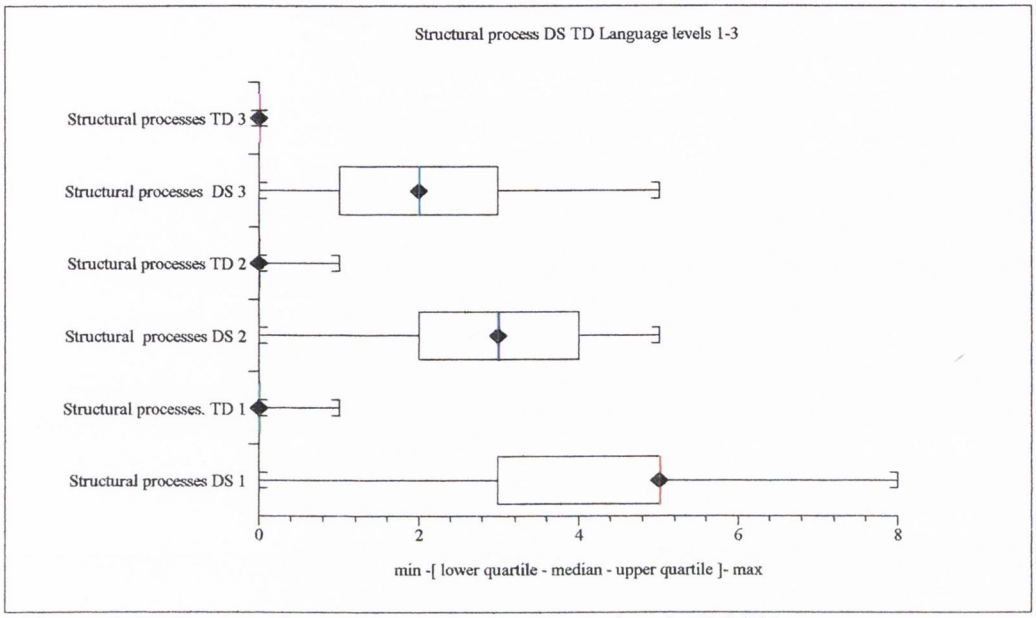


Figure 5.27: Structural processes across language levels: DS TD groups

Differences in the DS data at the three language levels tested as statistically significant at p= 0.0045 between levels 1 and 2 (Kruskal –Wallis H = -5.07) and to a lesser degree between levels 1 and 3 (H =-4.16; p= 0.0394). No statistically significant difference was found between level 2 and 3 in the DS data (*H* = -1.68; P = 0.8409). The TD data indicated no statistically significant differences (Levels 1-2 *H* = -1.42; P = 0.9159: levels 1-3; *H*= -2.14; p=0.6526: levels 2-3 *H*= -1.55; p=0.8827).

Inter group differences tested statistically significant at all levels.

Table 5.18 Inter group comparisons for structural processes:
(Kruskal –Wallis q = 4.03)

Structural	TD 1 n=38	P		TD 2 n=29	P		TD 3 n=8	P	
DS 1 n=38	10.44	< 0.0001	***	-9.79	< 0.0001	***	-6.16	0.0002	***
DS 2 n=29				-9.13	< 0.0001	***	-5.96	0.0004	***
DS 3 n=8							-4.59	0.0147	*

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Structural processes showed negative correlations with intelligibility at language level 1 (table 5.19) for both groups but the pattern of association varied between groups at later levels with the DS group showing no statistically significant associations and the association in the TD group increasing in strength.

Table 5.19 Correlations: Intelligibility and structural processes

Structural	**DS**				**TD**				
Language level	r		p		n	r	Negative		
1 n=38	-0.41	Moderate	0.0111	NS	38	-0.51	Moderate	0.0011	**
2 n=29	0.13	V. weak	0.4948	NS	29	-0.62	Strong	0.0004	***
3 n=8	-0.27	Weak	0.5008	NS	8	-1	V. strong	<0.0001	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Place processes

Place processes were more evident in the DS data at all levels as summarised on table 5.20.

Table 5.20 DS TD Descriptive summary: Place processes

Place	DS				TD				
Language level	Mean	SD	Median	Range	n	Mean	SD	Median	Range
1 n=38	.89	.83	1	3	38	.26	.45	0	1
2 n=29	0.79	.77	1	2	29	.17	.38	0	1
3 n=8	.25	.46	0	1	8	.12	.35	0	1

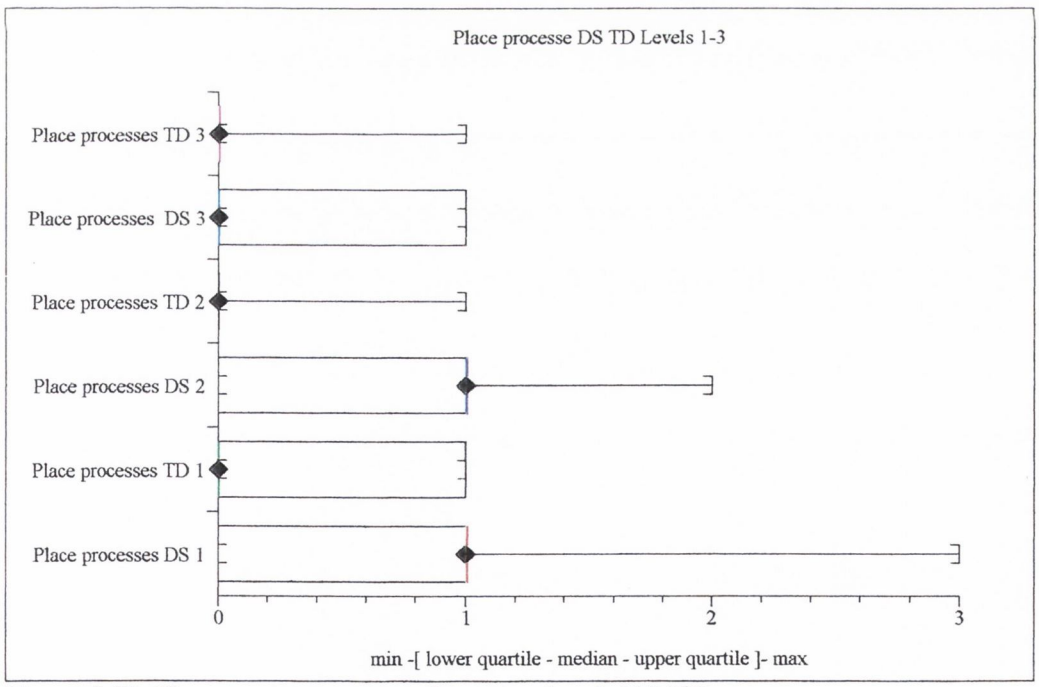


Figure 5.28: Place processes across language levels DS TD groups

Pairwise comparisons of DS place processes in the DS subgroups at the three language levels indicated no statistically significant differences (Kruskal – Wallis 1-

2: H = -0.58; P =0.9985: 1-3: H = -3.07; p = 0.2501: 2-3 H= -2.56; P= 0.9522). The TD data also showed no significant differences between levels (1-2: H = -1.24; p = 0.9522: 1-3: H =-1.16; p = 0.9633: 2-3 H= -0.45; p= 0.9996).

Inter group comparisons found significant differences between the DS and TD subgroups at levels 1 and 2.

Table 5.21 Place processes: Inter group comparisons: Kruskal –Wallis

Place	TD 1 n=38	P		TD 2 n=29	P		TD 3 n=8	P	
DS 1n=38	-5.28	0.0026	*	-5.75	0.0007	**	-3.76	0.083	NS
DS 2 n=29				-4.84	0.0083	*	-3.24	0.197	NS
DS 3 n=8							-0.88	0 .9896	NS

Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Place processes showed no significant correlations with intelligibility in the DS groups while the pattern of association increased in significance for the TD groups over the three language levels (table 5.22).

Table 5.22 Correlations: Intelligibility and place processes

Place	DS				TD				
Language level	Rho	Positive				Rho	Negative	p	
1 n=38	0.13	Very weak	0.4387	ns	n=38	-0.54	Moderate	0.0005	***
2 n=29	0.35	Weak	0.0616	ns	n=29	-0.66	Strong	0.0001	***
3 n=8	0	Very weak	0.9768	ns	n=8	1	Very strong	<0.0001	***

*** Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level**

Manner processes

Manner processes were more prevalent in the DS data from all subgroups Mean and median scores indicated an increased prevalence of these processes in the DS group at the base language level. Table 5.23 summarises descriptive data on the groups.

Table 5.23 Descriptive statistics: Manner processes

Manner	DS				TD				
Language level	Mean	SD	Median	Range		Mean	SD	Median	Range
1 n=38	2.76	2.16	3	7	n=38	1	.93	1	3
2 n=29	2.65	1.39	3	6	n=29	.34	.77	0	3
3 n=8	2.5	1.07	3	3	n=8	.12	.35	0	1

Changes in mean scores were similar for both groups over the three levels. Median differences and the spread of scores for the DS and TD subgroups are illustrated by figure 5.29.

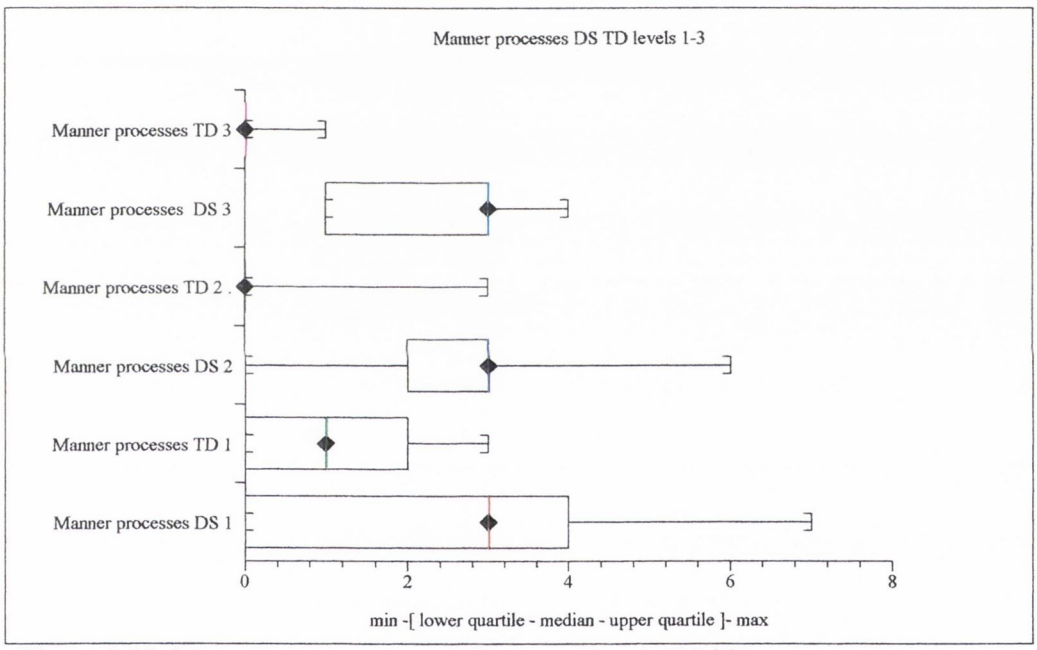


Figure 5.29: Manner processes across language levels DS TD groups

Median scores for the DS group did not change over the three language levels while the TD group showed changes from level 1 to 2.

Intra and inter group comparisons for manner processes were tested for significance using the Kruskal –Wallis. Pairwise comparisons of DS manner processes at the three language levels indicated no statistically significant differences (1-2: H =-0.38; p= 0.9998: 1-3: H= -0.50; p= 0.9993: 2-3 H =-0.19; p=

>0.9999). The TD data approached significance between levels 1-2 only with H= -4.43; p = 0.0215 (Levels 1-3: H = -3.54; p = 0.1232: 2-3 H= -0.84; P= 0.9914).

Table 5.24 Manner processes: Inter group comparisons (Kruskal –Wallis (q = 4.03)

Manner	TD 1 n=38	P		TD 2 n=29	P		TD 3 n=8	P	
DS 1 n=38	-5.13	0.0038	*	-6.78	<0.0001	***	-4.48	0.0193	*
DS 2 n=29				-8.11	<0.0001	***	-5.63	0.001	**
DS 3 n=8							-4.86	0.0077	**

Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

There were statistically significant differences between the DS and TD subgroups on manner processes at all levels.

Manner processes did not show any statistically significant correlation with intelligibility in the DS data but strong negative correlations were present in the TD data across all language levels (table 5.25)

Table 5.25 Correlations: Intelligibility and Manner processes

Manner	**DS**				**TD**				
Language level	Rho	All positive	p			Rho	All Negative	P	
1 n=38	0.09	V. Weak	0.6005	NS	n=38	-0.77	Strong	<0.0001	***
2 n=29	0.002	V. Weak	0.9888	NS	n=29	-0.70	Strong	<0.0001	***
3 n=8	0.22	Weak	0.5821	NS	n=8	1	V. Strong	<0.0001	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Summary: Speech intelligibility and Process type

All process types occurred with greater frequency in the group with Down syndrome than in the typically developing group. Analysis by process type identified 22 process types in the data from the DS group compared to 7 in the TD data. Correlations between process type and intelligibility tested as significant for all types in the TD data. This pattern was not found in the DS data where only structural processes tested as significant.

5.5. Speech intelligibility levels and phoneme inventories

Down Syndrome group data

Phoneme inventories were rated on a three point scale and analysis indicated that scores ranged from 1-3 with a median of 2 (mean 2.72 SD 0.58). Data analysis indicated that 77% of the participants in the DS group scored at the late developmental level, 15% at the middle and 7% at the early level.

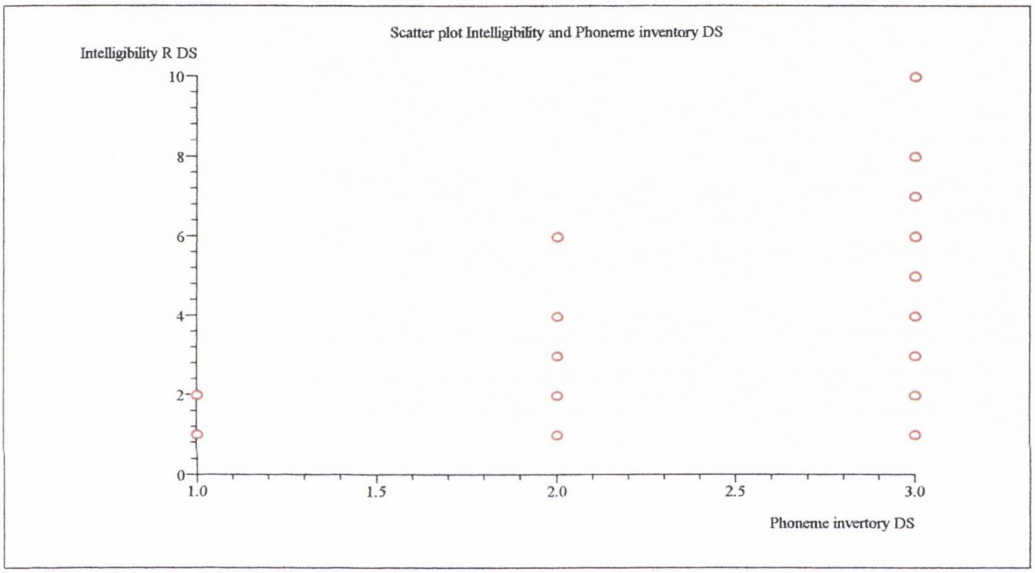


Figure 5.30 Intelligibility and phoneme inventories

Analysis of data indicted a moderate positive correlation, statistically significant at $P<0.0001$, between intelligibility and developmental levels in phoneme inventories ($r = 0.55$; $N = 75$).

Comparison of phoneme inventories from DS group with those of the target language

The data were further analysed in order to identify features possibly concealed by the broad three level developmental classification system used for quantitative evaluation. This analysis sought to identify phonemes absent from the inventories and any additional non target language phonemes.

Phonemes absent

Twenty-nine participants (36 %) presented with incomplete inventories. Analysis of phonemes absent from the inventories in DS group indicated that the consonants omitted crossed all developmental levels: - early /w h ŋ j/, middle /f v k g tʃ dʒ/and late /s z ʃ ʒ ɹ/.

Table 5.26 Phonemes absent from inventories in DS group

	Bi-labial	No.	Labio dental	No.	Inter dental	No.	Dental alveolar	No.	Palatal	No.	Velar	No.	Glottal	No.
Nasal	m						n				ŋ	2		
Plosive	p b	1					t d	1			k g	2		
Fricative			f v	9	θð	nt	s z	6	ʃʒ	7				
Affricate									tʃdʒ	11				
Approximant	w	7							l ɹ j	4 14 6			h	11

Nt = not tested

Table 5.26 shows the number of samples showing omission of each type of phoneme. The majority of phonemes absent belonged to the three sound classes, fricatives /f v s z ʃʒ/, affricates /tʃ dʒ/, and approximants /l ɹ j/. The main process influencing fricatives and affricates was stopping, while approximants were, in most instances deleted.

Additions

Non target language phonemes were present in the inventories of 16 participants in the DS group. Patterns of addition are summarised in table 5.27. The majority of additions were fricatives and individual analysis indicated that these were influenced by fronting or backing processes. Bi-labial fricatives, /ɸβ/ were used in place of labio-dental /f v/ while, palatal /ç/, velar /ɤ χ/ or glottal /ɦ/ fricatives replaced dental /alveolar /s z/, and palatal fricatives /ʃʒ/.

Glottal stops /ʔ/ occurred in two samples both indicating backing of place. This was confined to dental and velar stops in one while in the other both fricatives

and stops were backed. Lateral release of dental, alveolar or palatal fricatives and affricates occurred in six samples.

Table 5.27 Additional phonemes present in DS samples

	Bi labial	No.	Labio dental	Inter dental	Dental alveolar	No.	Palatal	No.	Velar	No.	Glottal	No.
Nasal												
Plosive											ʔ	2
Fricative	ɸβ	4			ɬ ɮ	6	ç	1	ɤ χ	1	ɦ	2
Affricate												
Approximant												

Typically developing group data

Phoneme inventories were fully developed by the majority of the TD group as indicated by a median score of 3, and a mean score of 2.8. (S.D. 43). Data analysis indicated that 81 % of the participants in the group scored at the late developmental level, 17% at the middle and 1% at the early level.

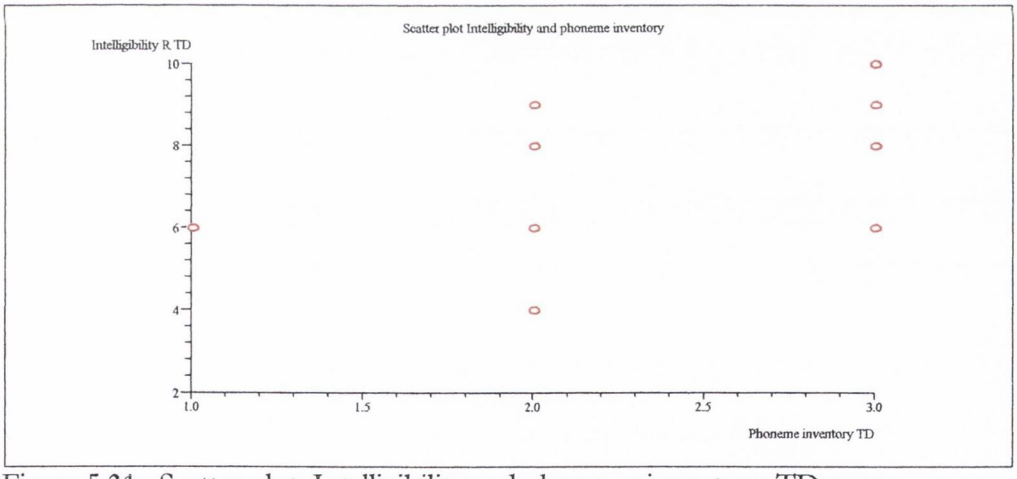


Figure 5.31. Scatter plot: Intelligibility and phoneme inventory: TD group

There was a moderate positive relationship between intelligibility and phoneme inventory with r = 0.58; p=< 0.0001; N=75.

Comparison of phoneme inventories from TD group with those of the target language

Samples were scanned to identify phonemes absent from the inventories and any additional non target language phonemes.

Phonemes absent

Twenty-one participants (28%) in the typically developing group presented with incomplete inventories. The consonants omitted belonged to the middle /k g tʃ dʒ/ and late / s z ʃ ʒ ɹ/ developmental levels. Analysis of phonemes omitted by class indicated that the majority of these belonged to the three sound classes: - fricatives / s z ʃʒ /, affricates / tʃdʒ /, and approximants /ɹ/. Table 5.28 shows the number of incomplete inventories and the omitted phonemes.

Table 5.28 Phonemes absent from inventories- typically developing group

Bilabial	No.	Labio dental	No.	Inter dental	No.	Dental /alveolar	No.	Palatal	No.	Velar	No.	Glottal	No.
m						n				ŋ			
p b						t d				**k g**	**4**		
		f v		θð	**nt**	s z	**12**	ʃʒ	**11**				
								tʃdʒ	**5**				
w								l ɹ j	**10**			h	

Nt = not tested

Place processes appeared to be influencing plosives and approximants with /k g/ were fronted to /t d/ and /ɹ/ signalled by /w/. Manner process appeared to be the main influence on fricatives and affricates with / s z ʃ tʃdʒ / signalled by dental/alveolar stops.

Additions

There were no non target language sounds evident in the TD data.

Inter-group comparison: Phoneme inventory: DS and TD groups

Phoneme inventory scores showed moderate positive correlations with intelligibility in both groups (DS r = 0.55; p< 0.0001; N=75: TD r = 0.58; p< 0.0001; N=75). Comparison of phoneme inventory scores indicated no significant differences between the groups (U= -59; p= 0.5529). The numbers of participants at early, middle and late developmental levels are illustrated in figure 5.32.

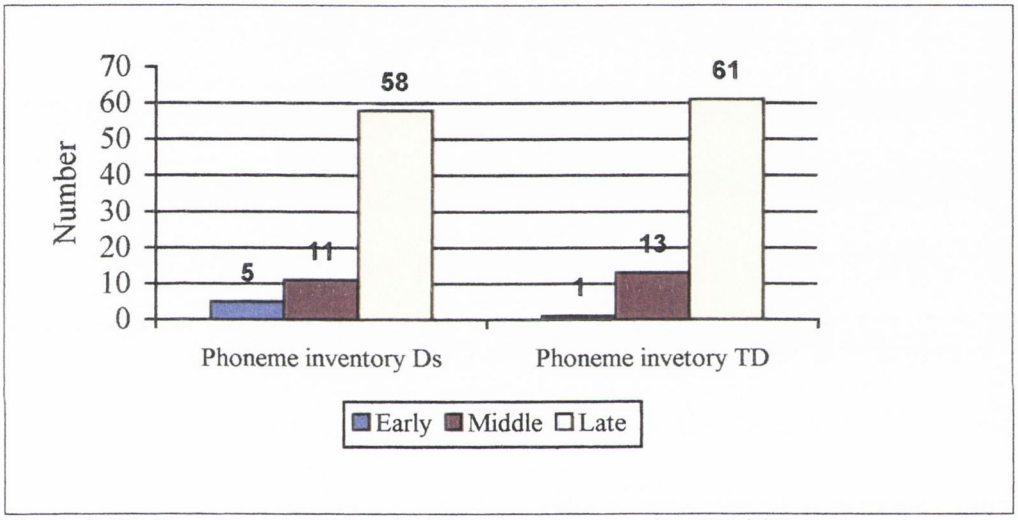


Figure 5.32. Developmental levels: Phoneme inventories: DS TD groups

Analysis and comparison of phoneme inventories identified two possible factors which could contribute to lower intelligibility in the DS group.

Omissions

Phonemes were omitted across all phoneme developmental levels and sound classes in the DS group while the majority of omissions in TD inventories were at the middle and late developmental stage. The phonemes omitted and the number of participants showing this reduction in their inventories are summarised in table 5.29.

Table 5.29 Phonemes absent from inventories: DS and TD groups

Phonemes	Level	DS	TD
w	Early	7	
p b	Early	1	
t d	Early	1	
ŋ	Early	2	
h	Early	11	
k g	Middle	2	4
f v	Middle	9	
tʃ dʒ	Middle	11	5
s z	Late	6	12
ʃ	Late	7	11
l	Late	4	
ɹ	Late	14	10
j	Late	6	

Additions

Non target language phonemes were present in the inventories of 16 participants (21%) in the DS group but none were found in the data from the TD group.

Developmental patterns: Phoneme inventory

There were no significant developmental differences evident between the groups on phoneme inventory as measured in this study. Phoneme inventories showed little change across the three language levels with the DS group only showing a significant difference between levels 1 and 2 in (Kruskal-Wallis q = 4.03 p = 0.0083).

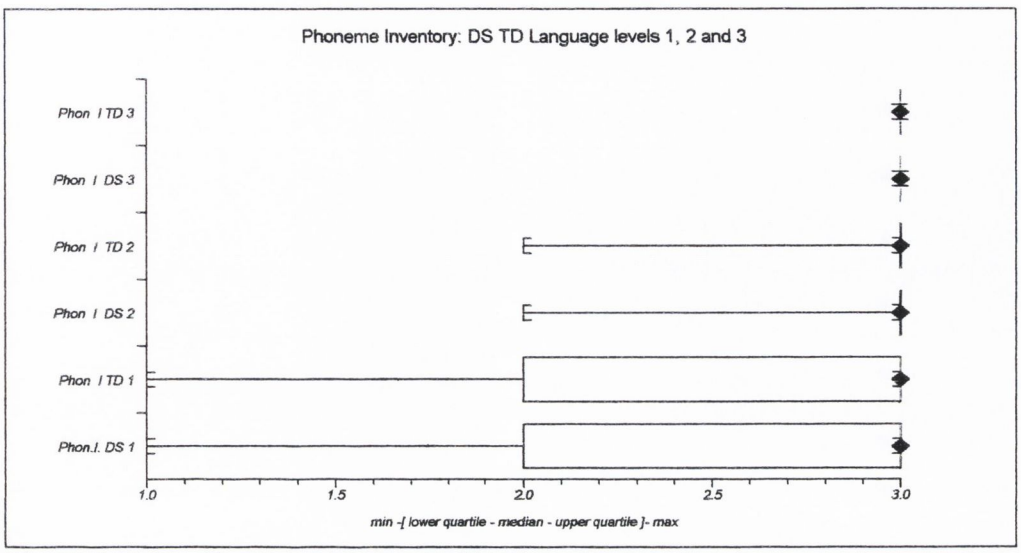


Figure 5.33 Developmental patterns: Phoneme inventories

Summary: Speech intelligibility and phoneme inventories:

Phoneme inventory scores did not show any statistically significant difference between the groups. Qualitative analysis of inventories indicated higher levels of omissions of target language phonemes in the DS group than was found in data from the TD group. Inventories in the DS group also showed the addition of phonemes not required for contrast in the ambient language. The additional phonemes included bilabial, lateral, palatal and glottal fricatives. The addition of non-native language phonemes during the period of formal phonological development suggests a deviation from typical developmental patterns.

Summary: Speech intelligibility and phonological system development:

Significant correlations were found between intelligibility and all measures of the phonological system except process type in DS and TD groups (table 5.30). Assimilation processes were not significantly related to intelligibility for either group. Place and manner processes showed a significant relationship with intelligibility in the TD group but none in DS group.

Table 5.30 Summary of correlations between intelligibility and measures of the phonological system in DS and TD groups

	DS N=75	Sig.	TD N=75	Sig.
Intelligibility	r		r	
Percentage consonants correct	0.80	***	0.93	***
Number of processes	-0.36	**	-0.92	***
Process strength	-0.72	***	-0.91	***
Process type: Structural	-0.47	***	-0.57	***
Process type: Place	-0.08	ns	-0.56	***
Process type: Manner	- 0.09	ns	-0.81	***
Process type: Assimilation	- 0.26	ns	NA	
Phoneme inventory	0.55	***	0.58	***

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Percentage of consonants correct showed a strong positive correlation with intelligibility in both groups. Evaluation of developmental patterns indicated increases in PCC across the three language levels.

Process measures correlated negatively with intelligibility in both groups. The DS group data showed a greater number of active processes than the TD group. Structural processes were more evident in the DS data at all levels but did not feature to any significant extent in the TD data. Process strength measures also indicated differences between the groups.

Phoneme inventory showed a positive association with intelligibility in both groups. Quantitative analysis did not indicate any significant differences between the groups. Analysis of phoneme inventories indicated potentially clinically significant differences in omission and additional patterns found in the DS inventories when these were compared to the target language inventory.

5.6 Developmental patterns in phonological systems

Differences between the groups in intelligibility and speech measures at the base language levels imposed restrictions on comparative explorations of developmental patterns. The following trends were evident from analysis of the results:

- Percentage of consonants correct scores increased with language levels in both groups but the DS groups showed lower scores and greater variability than the TD groups at all levels.

- Both groups showed similar patterns of decreases in the number of active processes as language levels increased.

- Comparisons of developmental patterns in processes strength and type were limited by the differences between the groups at base level. Process strength decreased in both groups with increases in language levels but the DS group data indicated stronger processes at all levels. The DS samples showed a wider range of active processes at all language levels. The high number of structural processes in the DS groups indicated a persistence of processes restricting word and syllable structures which were suppressed in the TD groups by the base language level. These processes would be expected to be present at a significantly earlier stage in phonological development and their presence in data from children at the stage of formal language development could indicate a deviation from the typical developmental pathway.

- Data from both groups showed similar developmental patterns in mastering the phoneme inventories required for the target language.

These would indicate that the groups were following parallel paths in development of the components of the speech system measured in this study but the participants with Down Syndrome were progressing at a slower rate and with greater variability than their language age matched peers.

5.7 Characteristics or clinical markers of speech impairment associated with Down syndrome

Analysis of the results of speech measures indicated some possible characteristics or clinical markers of speech impairment in the DS group in this study.

- Percentage of consonants correct scores are frequently used clinically to determine the degree of speech impairment. Increases in PCC scores are typically associated with increases in intelligibility as was found in the TD group. This was not reflected in the DS group where reductions in correlations with intelligibility were evident as language levels increased. This could reflect compensatory measures utilised by the participants with Down syndrome in this group to maximize communication while retaining a phonological system at variance with the ambient language.

- The persistence of developmental processes into the stage of formal language development is considered clinically as a marker of speech impairment and often attributed to a speech delay pattern. The processes evident in the DS data were suppressed by the majority of the TD group by the base language age. The number strength and range of processes active in the DS group exceeded that clinically linked with delay patterns and would be considered as a clinical marker of specific speech impairment in other populations.

- Phoneme inventory scores did not show statistically significant differences between the groups but analysis of inventories indicated higher levels of omissions of target language phonemes in the DS group (53%) than was found in data from the TD group (28%). Inventories in the DS group also showed the addition of phonemes not required for contrast in the ambient language. The additional phonemes included bilabial, lateral, palatal and glottal fricatives. The addition of non - native language phonemes during the period of formal phonological development suggests a deviation from typical developmental patterns

5.8. Summary

Quantitative and qualitative differences were found between the speech of the participants with Down syndrome and that of the group of language age matched typically developing children.

Speech intelligibility levels increased with competency levels in general language skills in both groups but results indicated that the participants in the DS group differed from the TD group in the rate of development of intelligible speech relative to general language skills. Intelligibility scores in the DS group were significantly lower than in the TD group at the base language age of 24 months and remained lower over the developmental language period studied. Speech intelligibility in the DS group studied showed a protracted period of development relative to language skills.

Comparison of speech patterns between the groups suggested that phonological system development in the DS group was out of synchrony with general language from the early stages of formal language development. Phonological development in the DS group showed restrictions on phonological contrasts, a higher number of strong active processes and reduced intelligibility than was evident in the TD group. The developmental patterns found in the DS group reflected those reported from studies of typically language developing children during early language development but intelligibility was compromised by the number and strength of developmental processes persisting into the stage of formal language development.

CHAPTER 6

RESULTS OF STUDIES 2 AND 3

6.1 Introduction

Studies 2 and 3 asked questions on possible relationships between speech intelligibility, restricted phonological systems and developmental levels in vocabulary, morphology and syntax as components of language form. Data obtained from a group of 40 participants selected from the larger group used in Study 1 were explored to identify associations between speech and other components of the verbal language system (Participant selection described in 4.4; Characteristics outlined in Appendix 6.1).

Language ages in the group were within the 24–81 month range while chronological ages ranged from 50–264 months. Discrepancies between chronological age and general language scores are illustrated in figure 6.1.

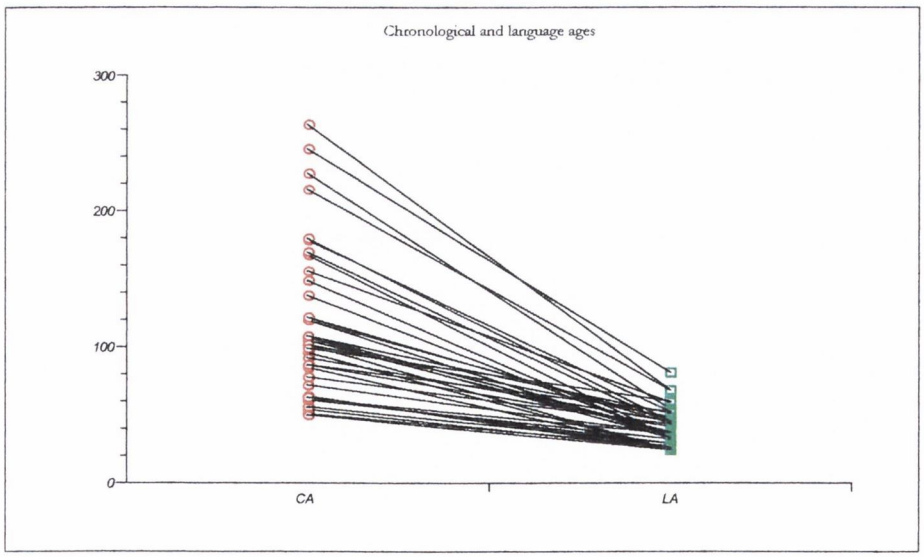


Figure 6.1 Chronological and language age levels.

These studies explored relationships between speech measures and developmental levels in vocabulary, morphology and syntax as factors, which may contribute to this discrepancy.

Study 2

Data and results from Study 2 are presented in 6.2 to 6.6. This study examined relationships between restricted phonological systems and developmental levels in other components of receptive and expressive language

The questions asked were

6.3 Is speech intelligibility level associated with levels of development in general language, or in receptive or expressive, vocabulary, morphology or syntax?

6.4. Do consonants correct ratings as a measure of the phonological system show patterns of association with levels of development in receptive or expressive vocabulary, morphology or syntax?

6.5. Do the number of developmental processes active in speech samples show patterns of association with levels of development in receptive or expressive vocabulary, morphology or syntax?

6.6. Does process strength correlate with developmental levels in receptive or expressive vocabulary, morphology or syntax?

6.7. Does system rating correlate with developmental levels in receptive or expressive vocabulary, morphology or syntax?

The hypothesis was that restrictions on the phonological system would not be associated with specific difficulties with the formal components of language.

Study 3

Additional data obtained from this group over a thirty month period were analysed to explore changes over time. Results from these analyses are presented in 6.10 –6.13. with the following questions addressed:

6.11. Is accelerated change in intelligibility reflected in changes in the phonological system?

6.12. Are periods of change in phonological systems associated with changes in other components of language?

6.13. Are there similarities between patterns of change in the phonological systems of individuals with a Down Syndrome and those encountered across languages during periods of acquisition and change?

The hypothesis was that changes in the phonological system would occur independently of other components of the formal language system in children with speech impairment.

6. 2. Speech and language measures

The following aspects of the speech system were measured: intelligibility level, percentage of consonants correct, number of processes, process strength, and system rating. Descriptive statistics for the group on these measures are presented in table 6.1.

Table 6.1. Descriptive statistics: Speech measures

DS N= 40	Mean	SD	Median	Range
Intelligibility level	4.53	2.04	4.5	9
Percentage of consonants correct	44.58	22.49	45.5	76
Process strength	14.95	5.55	15	17
Number of processes	9.07	2.66	9	11
System rating	5.73	1.47	6	6

Scores on percentage of consonants correct, number of processes and process strength were converted into rated scores (as described in 4.6) in order to provide common baselines for comparisons with measures of receptive and expressive vocabulary, morphology and syntax. Tables 6.2 and 6.3 present descriptive summaries of the speech measures, while 6.4 summarises language ratings.

Table 6.2. Descriptive summaries: Rated scores: speech measures.

N= 40	Mean	SD	Median	Range
Consonants correct rating	4.55	2.15	4.65	6.8
Process number rating	5.13	1.59	5	8
Process strength rating	2.55	2.50	2	8

Raw scores were used for comparison of process types and system rating with language measures.

Table 6.3: Process type and system rating: descriptive statistics

Process type (N=40)	Mean	SD	Median	Range
Structural	4.525	1.66	5	7
Place	0.95	0.85	1	3
Manner	3.5	1.78	3	7
System rating	5.73	1.47	6	6

Table 6.4. Descriptive summaries: Rated scores: Language measures.

Rated scores (N= 40)	Mean	SD	Median	Range
Language rating	3.05	2.14	2	9
Receptive vocabulary	1.55	1.84	1	8
Receptive morphology	0.93	1.72	0	7
Receptive syntax	0.85	1.44	0	7
Expressive vocabulary	2.83	2.47	2	8
Expressive morphology	1.48	2.21	0	9
Expressive syntax	2	2.36	1	8

The relationships between performance on the different speech and language measures were calculated using Spearman's rank correlation. The results of the

analyses of relationships between intelligibility, consonants correct rating, process number, process strength, system rating and developmental levels in general language, and in vocabulary, morphology and syntax are presented in the sections which follow.

Oral structure and functioning

Results from evaluations of oral movement rate and range functioning indicated that participants were presenting with severe difficulties in both aspects with all rated at level two on the standard clinical form.

Auditory acuity

All participants passed hearing screening tests at 30 dB at initial and final assessments in study 3. Clinical notes indicate that 4 (25%) of the participants in group A experienced ear infections and associated hearing loss during the therapy episode. The incidence was lower in group B with only two participants showing hearing loss associated with ear infections.

6.3. Speech intelligibility and language measures

Intelligibility and language levels

Intelligibility ratings were correlated with ratings derived from scores on the Preschool Language Scale – R (Zimmermann et al., 1979) to explore the hypothesis that speech intelligibility would increase with developing language competence in participants with Down syndrome.

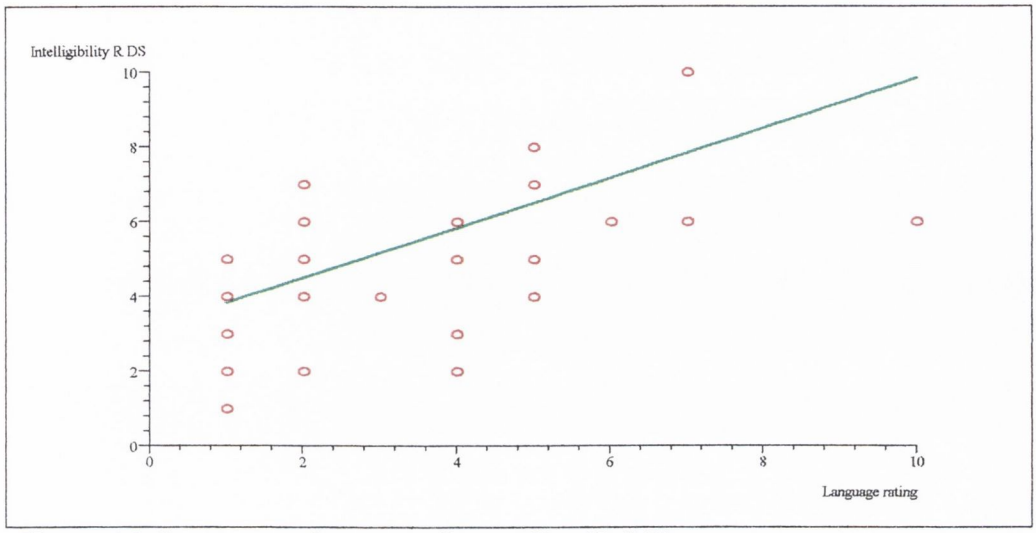


Figure 6.2: Language rating as predictor of intelligibility

General language levels showed a strong positive relationship with intelligibility ($r = 0.61$; $p<0.0001$; $N=40$) and non-parametric linear regression (figure 6.2) indicated that language level was statistically significant as a predictor of intelligibility for this group ($p< 0.0001$; tau b = 0.49; $N =40$)

Intelligibility and vocabulary

Speech intelligibility ratings were compared to estimates of receptive and expressive vocabulary derived from the results of the British Picture Vocabulary Scale (BPVS) and the Renfrew Action Picture Test (RAPT). The majority of the scores lay between ratings of zero and four indicating receptive vocabulary levels between 24 and 48 months (BPVS) and RAPT raw scores between 0 and 20 (figure 6.3).

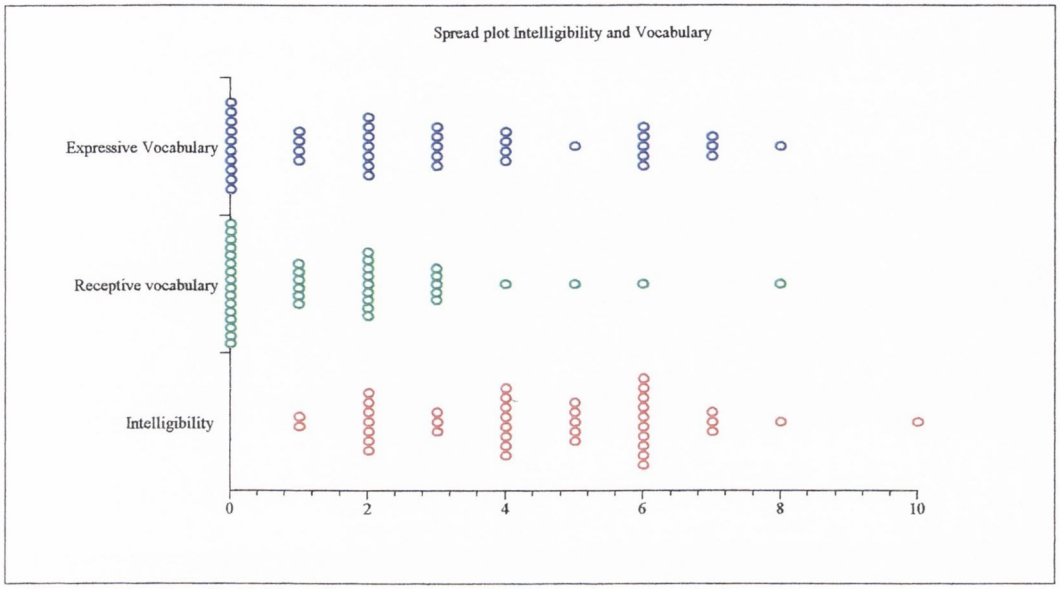


Figure 6.3: Intelligibility: Receptive and expressive vocabulary

The spread plot illustrates lower ratings for both receptive and expressive vocabulary than for intelligibility. Correlation coefficients indicated a moderate positive relationship between speech intelligibility and receptive vocabulary ($r = 0.53$: $P = 0.0006$: $N = 40$), and a weak non significant relation with expressive vocabulary. Receptive vocabulary results indicated a significant correlation with intelligibility and non-parametric linear regression confirmed that receptive vocabulary was significant as a predictor of intelligibility with $p \leq 0.001$ (tau b = 0.42; N=40).

Intelligibility and morphology

Speech intelligibility ratings were compared to ratings for morphology derived from the Test of Auditory Comprehension of Language – Revised (Carrow-Woolfolk, 1985) and the Renfrew Action Picture Test (RAPT). Receptive ratings gave a median score of 0.93 (range 7) while the expressive median score was 1.41 (range 9). Relationships between intelligibility and morphology were weak (table 6.5).

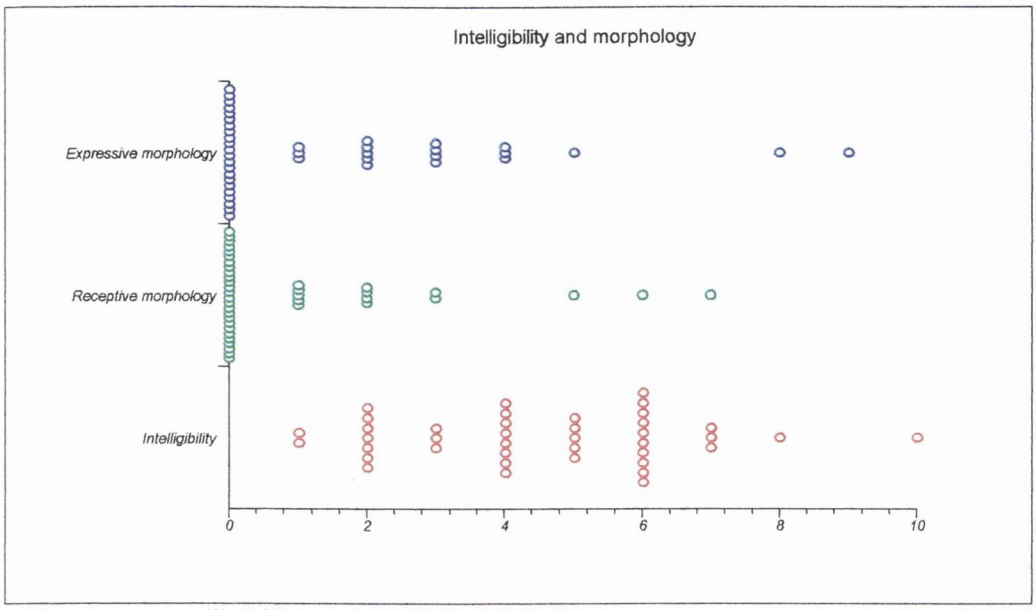


Figure 6.4: Intelligibility and morphology

Intelligibility and syntax

Syntax ratings were derived from scores on the Test of Auditory Comprehension of Language – Revised (Carrow-Woolfolk, 1985) and the Renfrew Action Picture Test (RAPT). The median score for receptive syntax was 1.44, while the expressive median was 2, with ranges of 7 and 8 as illustrated by figure 6.5. The relationship between intelligibility and receptive syntax was weak (table 6.5).

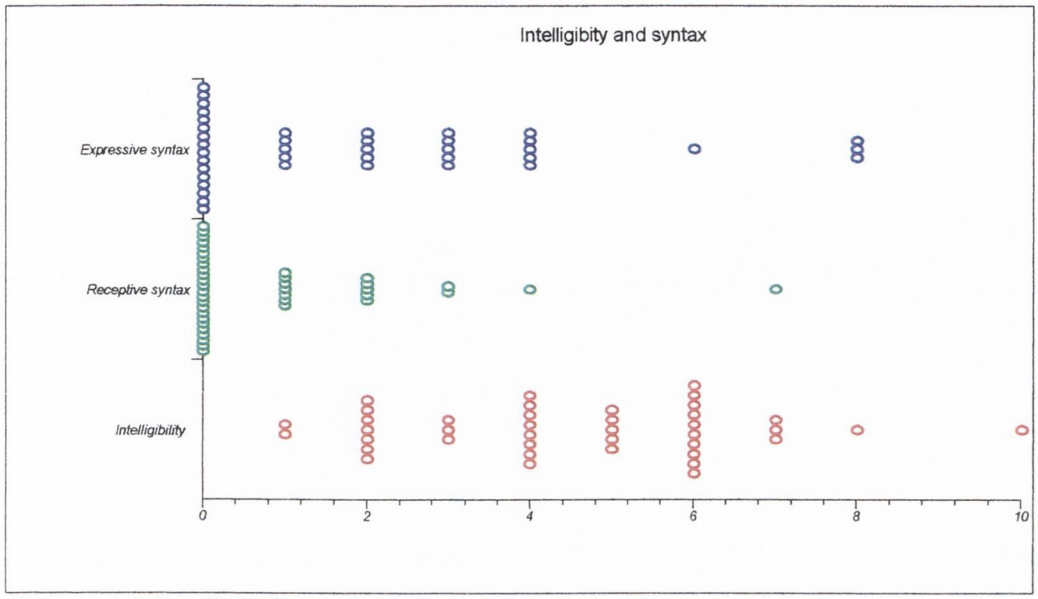


Figure 6.5: Intelligibility and syntax

Summary: Intelligibility and language measures

Speech intelligibility was positively associated with developmental levels in general language skills. Relationships between intelligibility and other components of language were weak.

Table 6.5: Correlations between intelligibility and language measures

Intelligibility (N=40)	r	**All positive**	P	
Language	0.61	Strong	<0.0001	***
Receptive vocabulary	0.53	Moderate	0.0006	***
Expressive vocabulary	0.24	Weak	0.1283	ns
Receptive morphology	0.31	Weak	0.0556	ns
Expressive morphology	0.34	Weak	0.0316	*
Receptive syntax	0.36	Weak	0.0246	*
Expressive syntax	0.25	Weak	0.1142	ns

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

6.4 Consonant correct and language measures

Consonant correct and language

Consonants correct ratings were derived from percentage of consonants correct scores. The median score was 4.65 with a range 6.8 as illustrated in figure 6.6. Correlation testing showed a significant relationship (r= 0.42; p= 0.0078; N=40).

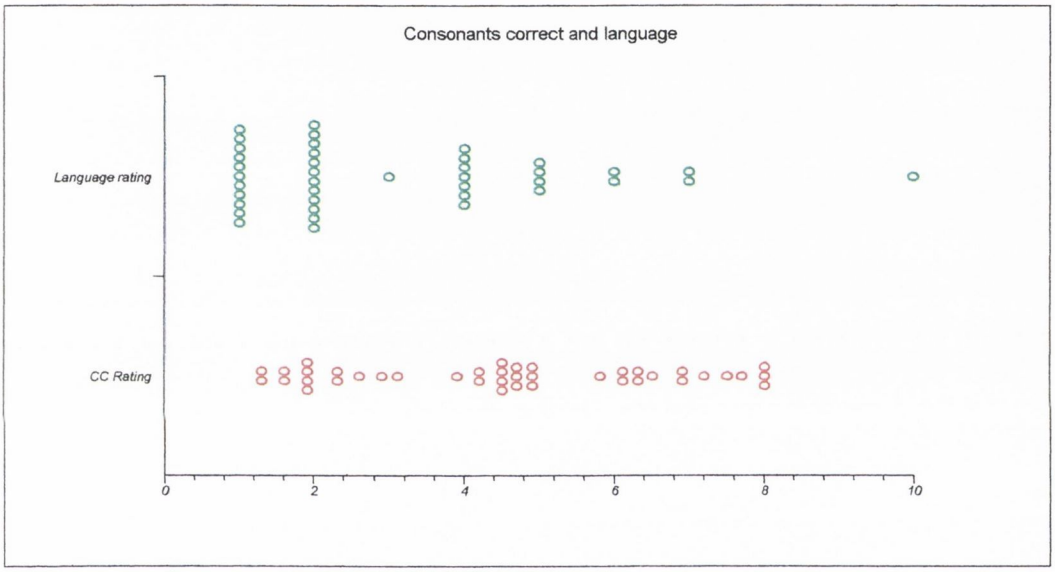


Figure 6.6: Consonant correct and language

Consonant correct and vocabulary

Correlation testing gave a significant positive relationship between consonants correct and receptive vocabulary r = 0.46; p=0.0033 (N=40).

Consonant correct and morphology

A moderate positive relationship was found between consonant correct ratings and receptive morphology (r = 0.40; p ≤0.01; N=40)

Consonants correct and syntax

The relationship between consonant correct ratings and receptive syntax was weak positive but statistically significant at the .05 level (r =0.33; p= 0.0357; N=40)

Summary: Consonant correct and language measures

Consonants correct rating showed moderate positive correlations with language, receptive vocabulary and morphology and a weak relationship with receptive syntax. There was no significant relationship with expressive language measures (table 6.6).

Table 6.6: Correlations: Consonants correct and language measures

Consonants Correct (N=40)	r	**All positive**	P	
Language	0.42	Moderate	0.0078	**
Receptive vocabulary	0.46	Moderate	0.0033	**
Expressive vocabulary	0.31	Weak	0.0557	ns
Receptive morphology	0.40	Moderate	≤0.01	**
Expressive morphology	0.31	Weak	0.054	ns
Receptive syntax	0.33	Weak	0.0357	*
Expressive syntax	0.22	Weak	0.1745	ns

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

6.5. Process number rating and language measures

Process number ratings and language

Process number ratings were derived from the total number of process scores. Ratings showed a median score of 5 and a range of 8. Testing using Spearman's correlation coefficient gave r = 0.54 (p=0.0004; N=40) indicating a moderate positive significant relationship.

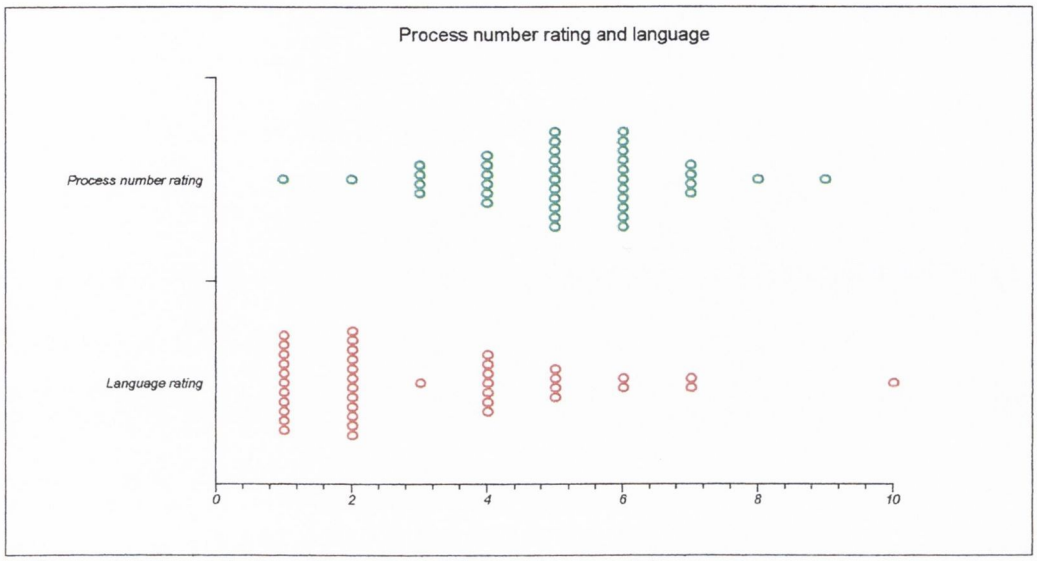


Figure 6.7 Spread plot: Process number ratings and language

Process number ratings and vocabulary

Process number ratings showed significant moderate positive relationships with both receptive and expressive vocabulary, with r =0.55 (p=0.0003; N=40) and r = 0.43 (p=0.0061; N=40) respectively.

Process number ratings and morphology

Process number ratings showed a significant positive moderate relationship with receptive morphology r=0.46 (p=0.0029; N=40), and a weak correlation with expressive morphology r= 0.38 (p= 0.0174; N=40).

Process number ratings and syntax

Relationships between process number and syntax measures tested as weak but significant, with receptive r =0.38 (p=0.0159; N=40) and expressive at r =0.33 (p= 0.0351; N=40)

Summary: Process number ratings and language measures

Process number rating gave moderate positive and significant correlations with language, receptive and expressive vocabulary and receptive morphology (table 6.7).

Table 6.7: Correlations between process number and language measures

Process number (N=40)	r	**All positive**	P	
Language	0.54	Moderate	0.0004	***
Receptive vocabulary	0.55	Moderate	0.0003	***
Expressive vocabulary	0.43	Moderate	0.0061	**
Receptive morphology	0.46	Moderate	0.0029	**
Expressive morphology	0.38	Weak	0.0174	*
Receptive syntax	0.38	Weak	0.0159	*
Expressive syntax	0.33	Weak	0.0351	*

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

6.6 Process strength and language measures

Process strength and language

The median score for process strength ratings was 2 (range 8) as illustrated in figure 6.8. Process strength correlated positively and significantly with language (r=0.48; p=0.0021; N=40)

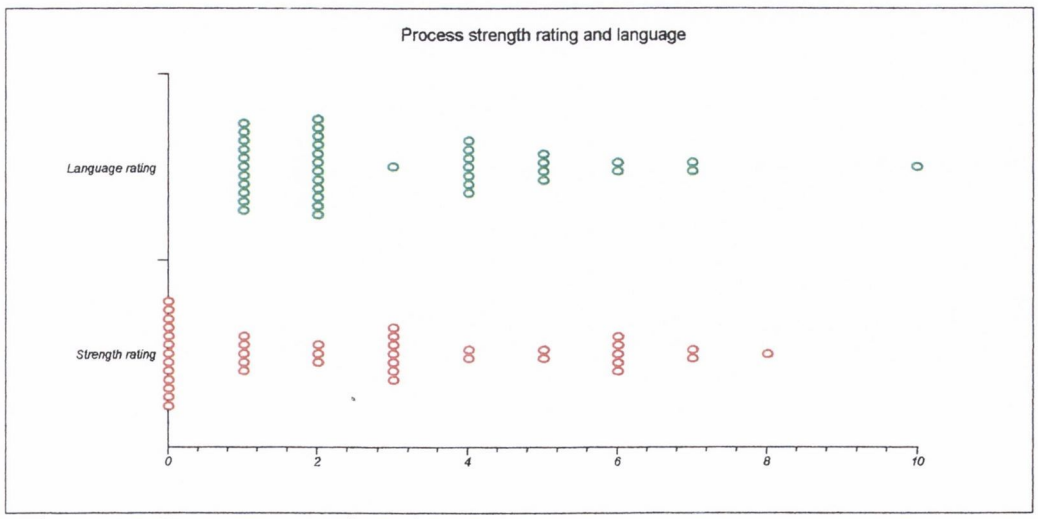


Figure 6.8: Process strength and language

Process strength and vocabulary

Process number ratings showed moderate positive significant relationships with both receptive and expressive vocabulary, with r =0.55 (p=0.0003; N=40) and r = 0.43 (p=0.0061; N=40) respectively.

Process strength and morphology

Receptive and expressive morphology showed weak positive but significant correlations with process strength (Receptive r =0.37: p=0.0208: Expressive r=0.36; p=0.0244; N=40)

Process strength and syntax

Process strength ratings gave a significant moderate positive correlation with receptive syntax (r=0.41; p=0.0091; N=40). Correlation with expressive syntax was not significant (r= 0.29; p=0.0718; N=40)

Summary: Process strength and language measures

Process strength showed moderate positive correlations with language, receptive and expressive vocabulary and receptive syntax. There was a weak relationship with receptive and expressive morphology.

Table 6.8: Correlations: Process strength and language measures

Process strength (N=40)	**r**	**All positive**	**p**	
Language	0.48	Moderate	0.0021	**
Receptive vocabulary	0.45	Moderate	0.0038	**
Expressive vocabulary	0.44	Moderate	0.0052	**
Receptive morphology	0.37	Weak	0.0208	*
Expressive morphology	0.36	Weak	0.0244	*
Receptive syntax	0.41	Moderate	0.0091	**
Expressive syntax	0.29	Weak	0.0718	ns

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

6.7 Process type and language measures

Raw scores for process type were used to calculate correlations between process type and language ratings. Descriptive statistics are summarised in table 6.9.

Table 6.9: Process type descriptive statistics

Process type (N = 40)	Mean	SD	Median	Range
Structural	4.53	1.66	5	7
Place	0.95	0.85	1	3
Manner	3.5	1.78	3	7

Process type and language

Structural processes showed a strong significant correlation with language r=-0.67 ($p \leq 0.0001$; N=40). These were no significant relationships between language and place or manner process scores.

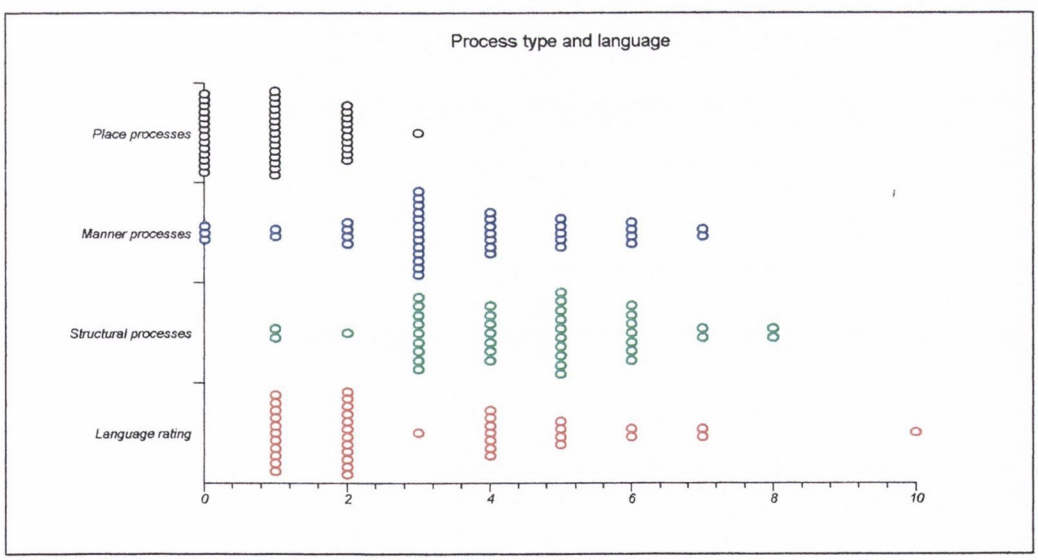


Figure 6.9: Process type and language

Process type and vocabulary

Structural processes showed a significant negative correlation with receptive vocabulary ($r = -0.65$; $p<0.0001$; $N=40$) and with expressive vocabulary (-0.47; $p=< 0.0023$; $N=40$). Place processes showed a weak but significant negative relationship with expressive vocabulary $r = - 0.38$ ($p=0.0155$; $N=40$).

Process type and morphology

Structural and place processes showed negative correlations with receptive morphology (Structural $r = -0.28$; $p=0.0761$: Place $r = 0.43$; $p =0.0055$; $N=40$). Both structural and place processes showed a moderate negative relationship with expressive morphology (Structural $r = -0.44$; $p=0.0051$; $N=40$: Place $r = -0.40$; $p=0.0107$; $N=40$).

Process type and syntax

Structural processes showed a moderate significant negative relationship with expressive syntax ($r = -0.42$; $p=0.0073$; $N=40$) and a weak relationship but significant with receptive syntax ($r = 0.35$; $p=0.029$; $N=40$). Place and manner processes gave weak correlations with receptive and expressive syntax.

Summary: Process type and language measures

Associations between processes by type and language measures were tested using Spearman's correlation coefficient. These correlations are summarized in tables 6.10 – 6.12.

Structural Processes

Table 6.10: Correlations: Structural processes and language measures

Structural processes (N=40)	r	**All Negative**	P	
Language rating	- 0.67	Strong	< 0.0001	***
Receptive vocabulary	- 0.65	Strong	< 0.0001	***
Expressive vocabulary	- 0.47	Moderate	0.0023	**
Receptive morphology	- 0.28	Weak	0.0761	ns
Expressive morphology	- 0.44	Moderate	0.0051	**
Receptive syntax	- 0.35	Weak	0.029	*
Expressive syntax	- 0.42.	Moderate	0.0073	**

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Structural processes showed negative correlations with all language measures. There were significant correlations with all language measures except receptive morphology.

Manner processes

Table 6.11: Correlations: Manner process and language measures

Manner (N=40)	r	**All Negative**	P	
Language rating	-0.24	Weak	0.1381	ns
Receptive vocabulary	- 0.17	Very weak	0.2722	ns
Expressive vocabulary	- 0.12	Very weak	0.4507	ns
Receptive morphology	- 0.17	Very weak	0.2884	ns
Expressive morphology	- 0.04		0.7759	ns
Receptive syntax	- 0.09		0.569	ns
Expressive syntax	- 0.006		0.9682	ns

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

There were no statistically significant relationships between manner processes and language measures

Place Processes

Table 6.12 Correlations: Place processes and language measures

Place processes (N=40)	r	**All negative**	p	
Language rating	-0.28	Weak	0.0838	ns
Receptive vocabulary	- 0.17	Very weak	0.3019	ns
Expressive vocabulary	- 0.38	Weak	0.0155	*
Receptive morphology	- 0.43	Moderate	0.0055	**
Expressive morphology	- 0.40	Moderate	0.0107	*
Receptive syntax	- 0.28	Weak	0.0794	ns
Expressive syntax	- 0.33	Weak	0.0392	*

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Place processes showed a significant moderate negative relationship with receptive and expressive morphology. Correlations with vocabulary and syntax were weak and significant for expressive aspects only.

6.8 System Rating and language measures

System rating and language

Language ratings yielded significant negative moderate correlations with ratings of the phonological system (r= - 0.47; p= 0.0023 N=40).

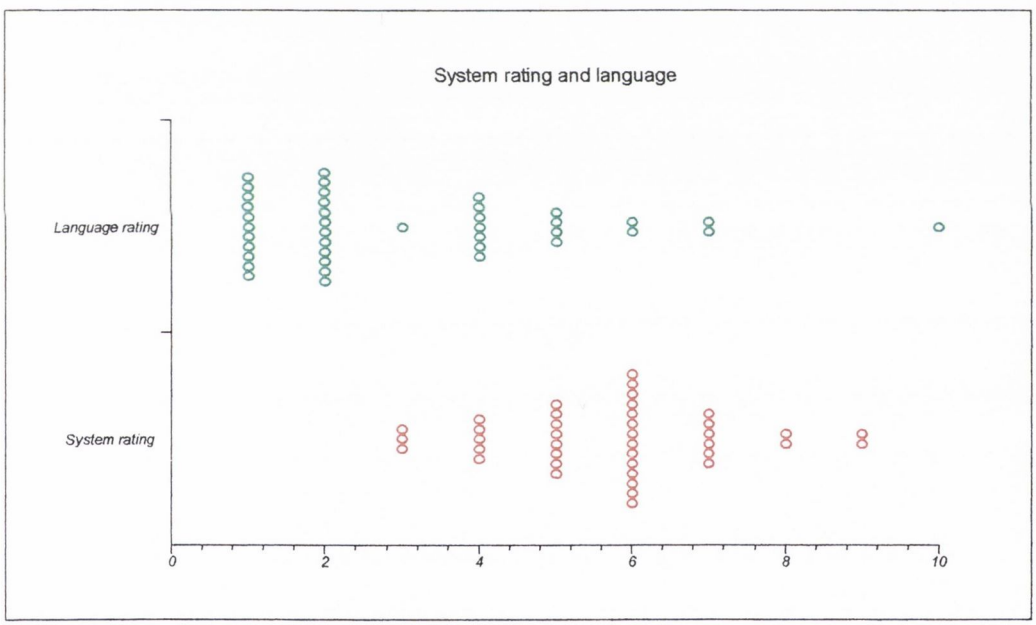


Figure 6.10: System rating and language

System rating and vocabulary

Spearman's correlation of system ratings and receptive vocabulary gave r= - 0.47 (p=0.0023; N=40). The relationship between expressive vocabulary and system rating was weak and non significant (r=- 0.25; p= 0.1571; N=40)

System rating and morphology

There was no significant correlation with morphology.

System rating and syntax

There was no significant correlation with syntax.

Summary: System rating and language measures

System rating showed weak negative correlations with all language measures with the exception of language rating and receptive vocabulary where a moderate negative relationship was significant (table 6.13)

Table 6.13: Correlations between System rating and language measures

System rating (N=40)	R	**All Negative**	P	
Language rating	- 0.47	Moderate	0.0023	**
Receptive vocabulary	- 0.47	Moderate	0.0023	**
Expressive vocabulary	- 0.25	Weak	0.1571	ns
Receptive morphology	- 0.16		0.3153	ns
Expressive morphology	- 0.16		0.3273	ns
Receptive syntax	- 0.25	Weak	0.115	ns
Expressive syntax	- 0.17		0.2763	ns

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

6.9 Summary

Speech intelligibility was associated with developmental levels in general language and vocabulary for the participants in this study.

- Speech intelligibility showed significant positive correlations with developmental levels in general language skills and receptive vocabulary.
- Relationships between intelligibility and other components of language were weak.

Restrictions in the phonological systems showed moderate correlations with developmental levels in general language and vocabulary.

- Consonants correct, process number, process strength, and system ratings all showed moderate positive correlations with language and receptive vocabulary.
- Process number, process strength, and the number of structural processes gave significant positive correlations with expressive vocabulary.

Relationships between consonants correct, process number, process strength, and system ratings and measures of morphology and syntax varied.

- Receptive morphology showed significant positive moderate correlations with consonants correct and process number, and a weak but significant relationship with process strength.
- Expressive morphology gave significant but weak positive correlations with process number and strength ratings.
- Receptive syntax showed a moderate correlation with process strength and weak relationships with consonants correct and process number.
- Expressive syntax showed a moderate significant negative correlation with structural processes and weak but significant positive relationships with process number and strength.

The hypothesis that restrictions on the phonological system would not be associated with impairments in the language system in this group of children and young adults with Down syndrome was not supported by these results.

6.10. Study 3: Introduction

Additional data obtained over a period of thirty months from participants in Study 2 were analysed to address the following questions:

6.11. Is accelerated change in intelligibility reflected in changes in the phonological system?

6.12. Are periods of change in phonological systems associated with changes in other components of language?

6.13. Are there similarities between patterns of change in the phonological systems of individuals with a Down syndrome and those encountered in languages during periods of acquisition and change?

Modification to the original study plan

The data were collected from two groups of participants over a thirty-month period during which accelerated gains in speech intelligibility occurred. Group B provided data from pre and post therapy measures while group A provided data at three points as outlined on table 6.14.

Table 6.14 Study 3 Time frame and data collection points

N=40	Time 1		Time 2		Time 3
Group A n=20	Pre-test 1	Indirect intervention	Pre-test 2	Direct intervention	Post-test
Group B n=20	Pre-test	Direct intervention	Post - test		

There were 20 participants in each group. Group A had 12 males and 8 females while B had 15 males and 5 females. Table 6.15 provides a summary of descriptive statistics on the groups at time 1. Participant characteristics are summarised in appendix 6.1.

Table 6.15: Group A and B time 1: Descriptive statistics

	Group A Time 1				Group B time 1			
	Mean	SD	Median	Range	Mean	SD	Median	Range
CA	102.15	42.73	99	177	125.4	65.79	108	214
LA	34.4	10.1	33	35	45.1	15.23	43.5	57
INT	4.3	1.72	4	5	4.75	2.34	5	9
PCC	44.2	21.37	45.5	67	44.85	22.15	46	76
S. R.	5.85	1.50	6	6	5.6	1.47	6	1

Group A was originally designated as a 'no treatment group' but as no control could ethically be placed on the many life experiences which foster speech development some changes be predicted. Information from carers at time 2 identified some factors which may have motivated changes in speech. All carers

had been made aware of the nature of speech impairment from project information and through attendance at the first assessment. Family members of sixteen participants (80%) had attended a one day workshop on ways to encourage language development at home. The no treatment period was therefore re-designated as indirect intervention. Differences between the groups were evaluated for significance using the Mann Whitney. The groups did not show significant differences at time 1 in chronological age, intelligibility, consonants correct, process measures or system rating but differences in scores reflecting general language skills were evident. Further differences, as summarised in table 6.16, developed between the groups while Group A were waiting for direct intervention.

Table 6.16: Differences between the groups on pre therapy measures

Group A (n= 20) Group B (n=20)	Time 1 A	Time 1 B		Time 2 A	Time 1 B	
Mann Whitney.	U	p		U	p	
Chronological age	166	0.3651	ns	195	0.8989	ns
Language age	**285.5**	**0.0196**	*	**400**	**<0.0001**	***
Language rating	104	0.0068	**	270	0.0541	ns
Intelligibility rating	221.5	0.5617	ns	180	0.5884	ns
Percentage consonants correct	199.5	0.9947	ns	271	0.0549	ns
Consonants correct rating	**202.5**	**0.952**	**ns**	**124**	**0.0394**	*
Process number rating	**137**	**0.0774**	**ns**	**308.5**	**0.0021**	**
Process strength rating	199	0.9822	ns	186.5	0.7161	ns
System rating	210.5	0.7767	ns	262	0.0861	ns

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Participants in group A showed gains in speech measures following the period of non-direct intervention. These resulted in significant differences in consonants correct and process number ratings, which are illustrated by figures 6.11 and 6.12 and will be discussed further in the next section.

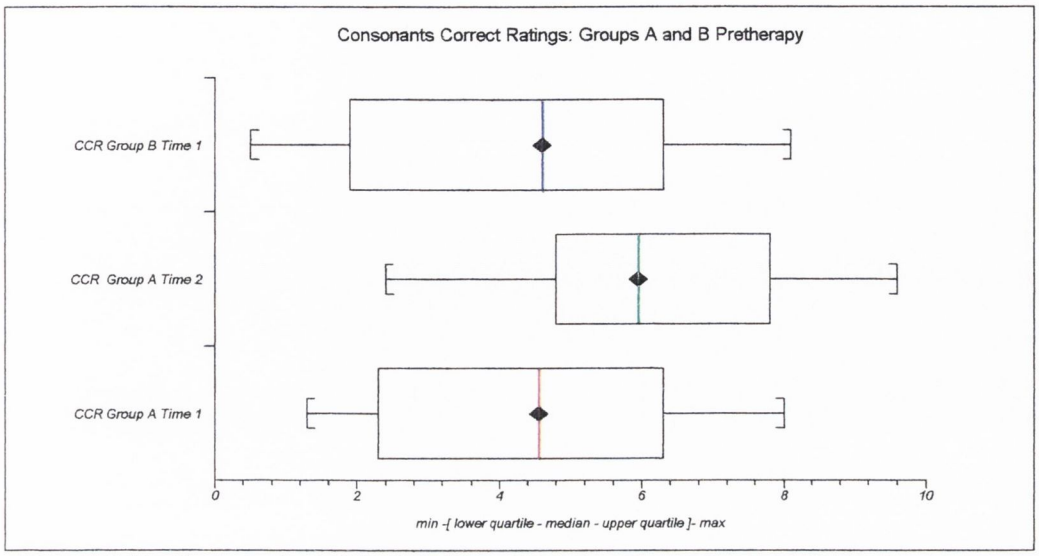


Figure 6.11: Groups A and B: Pre therapy: consonants correct ratings

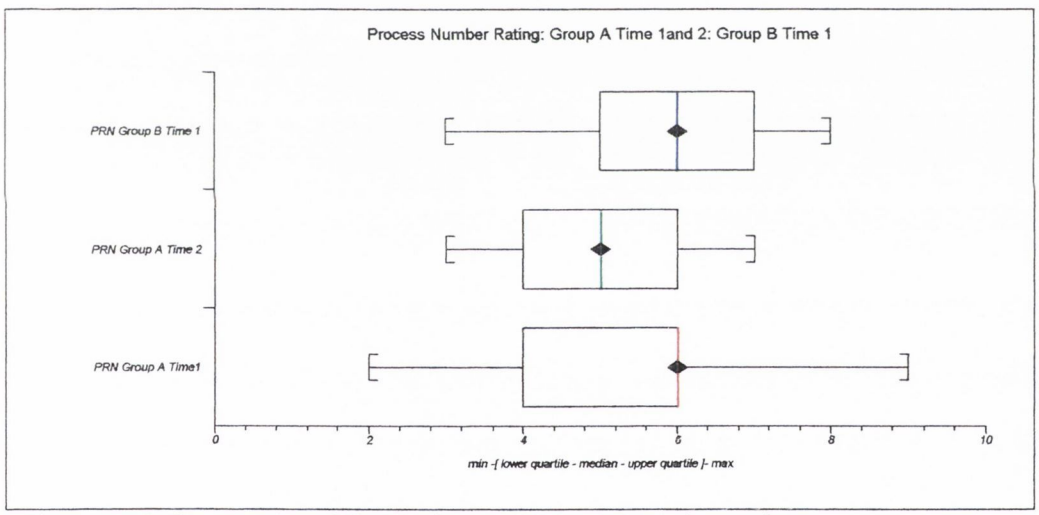


Figure 6.12 Groups A and B Pre therapy: process number ratings

As the groups differed significantly on pre therapy measures data from both groups were evaluated and are presented separately. Results from both groups for measures of phonological system changes are evaluated qualitatively in 6.14.

6.11 Changes in intelligibility and in the phonological system

Group A: Intelligibility

Participants in group A showed changes in intelligibility at times 1, 2 and 3 as illustrated in figure 6.13. Changes during the indirect intervention period were not statistically significant. The participants then attended for a period of therapy, which focussed on bringing about accelerated change in speech intelligibility. Changes in intelligibility ratings post therapy were significant at $P < 0.0001$ (Wilcoxon Med. Dif. = -3: n=20).

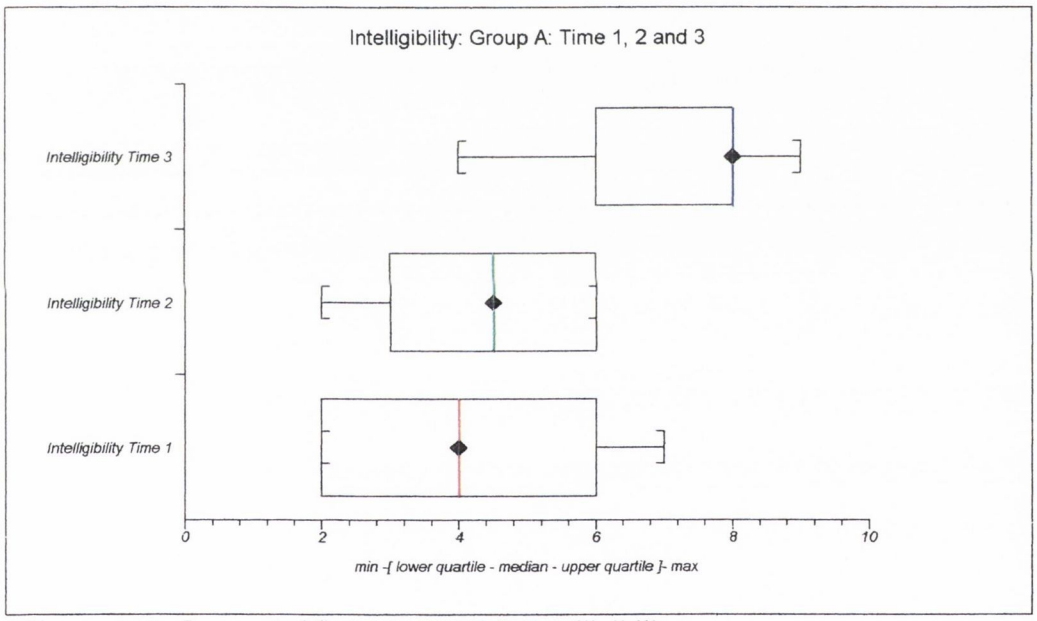


Figure 6.13: Group A: Times 1, 2 and 3: Intelligibility

Changes in intelligibility were accompanied by changes in all measures of the phonological system at times 1, 2 and 3 (table 6.17)

Table 6.17: Group A: Intelligibility and speech measures

Group A (n=20)	Time 1		Time 2		Time 3	
	Mean	Median	Mean	Median	Mean	Median
Intelligibility	4.3	4	4.35	4.5	7.5	8
PCC	44.2	45.5	59.85	59.5	78	75.45
CCR	4.42	4.55	6.04	5.95	7.55	7.8
Process number rating	6.85	7	4.75	5	5.35	6
Process strength rating	2.5	2.5	2.75	2	5.4	5.5
Process type						
Structural	4.6	5	4.8	5	2.55	2
Place	0.75	1	1.55	1	0.5	0
Manner	3.3	3	3	3	2.4	2.5
System rating	5.85	6	4.7	4.5	1.95	1

Differences between the groups in base, pre therapy and post therapy measures were tested for significance using the Wilcoxon signed ranks test (table 6.18)

Table 6.18: Group A: Changes in speech measures over time

Wilcoxon signed ranks (n=20)		Time 1-2	Sig.		Time 2-3	
Intelligibility	**0**	**0.7334**	**ns**	**-3**	**< 0.0001**	*******
PCC	-15	< 0.0001	***	-16	< 0.0001	***
CCR	-1.5	< 0.0001	***	-1.6	< 0.0001	***
Process number rating	0.5	0.2524	ns	-2	**< 0.0001**	*******
Process strength rating	-0.5	0.5771	ns	-2.5	**< 0.0001**	*******
Structural	0	0.6685	ns	2	**< 0.0001**	*******
Place	-0.5	0.0833	ns	1	**0.004**	**
Manner	0	0.5195	ns	0.5	0.0547	ns
System rating	**1**	**0.0002**	**	**2.5**	**< 0.0001**	*******

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Significant changes had occurred in percentage of consonants correct and in system rating scores during the pre intervention period (table 6.18). These changes were not reflected in any significant change in intelligibility. Significant change was evident in intelligibility and in all measures of the phonological system with the exception of place processes, between times 2 and 3.

Group B: Intelligibility

Participants in group B attended for therapy within one month of initial assessments. The group made significant gains in intelligibility as indicated by pre and post therapy measures (figure 6.14).

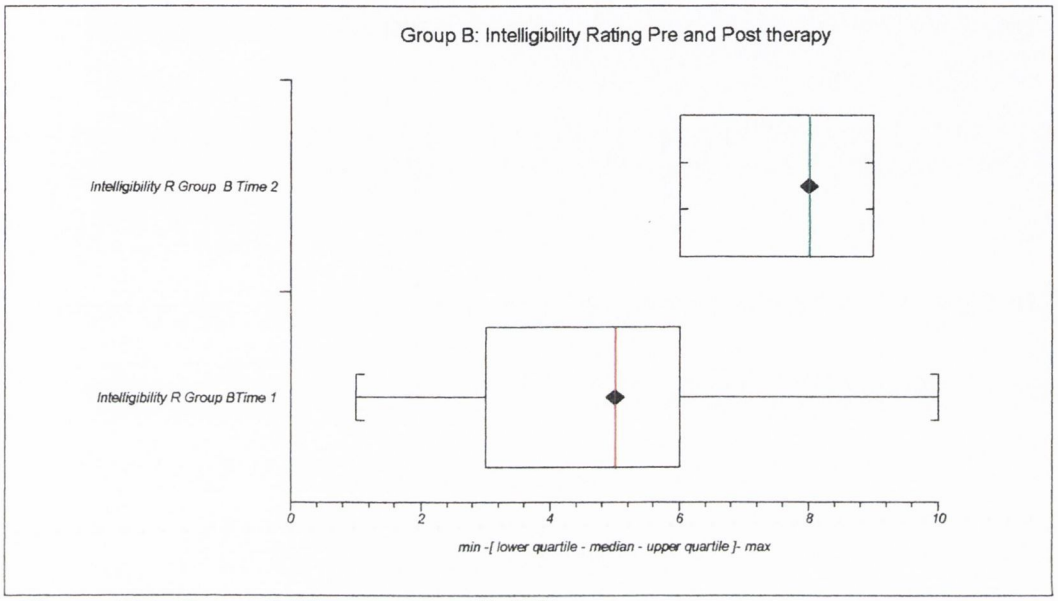


Figure 6.14: Group B Time 1-2: Intelligibility

Changes in intelligibility were accompanied by significant changes in measures of the phonological system as summarized on table 6.19.

Table 6.19: Group B: Changes in speech measures pre and post therapy

Wilcoxon signed ranks	Time 1		Time 2				
Group B (n=20)	Mean	Med.	Mean	Med.	M.dif.	p	
Intelligibility	**4.75**	**5**	**7.75**	**8**	**-3**	**< 0.0001**	***
PCC	**44.85**	**46**	**81.15**	**84.5**	**-36**	**< 0.0001**	***
CCR	**4.44**	**4.6**	**8.12**	**8.45**	**-3.65**	**< 0.0001**	***
Process number rating	**6.05**	**6**	**7.45**	**7**	**-1.5**	**0.0004**	***
Process strength rating	**2.6**	**2**	**6.35**	**7**	**-4**	**<0.0001**	***
Structural	**4.4**	**4**	**2.35**	**2**	**2**	**0.0003**	***
Place	0.45	0	0.2	0	0	0.1953	ns
Manner	4.25	3	2	2	2	0.5566	ns
System Rating	**2.6**	**2**	**6.35**	**7**	**3.5**	**< 0.0001**	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

6.12 Phonological system changes

6.12.i. Consonants correct

Consonants correct: Group A: Time 1-2

Comparison of group A data at times 1 and 2 indicated increases in mean and median scores for consonants correct which tested as significant at ≤ 0.0001 on the Wilcoxon. Analysis of changes in individual scores indicated that 6 participants had shown gains of over 20 points in PCC scores (figure 6.15).

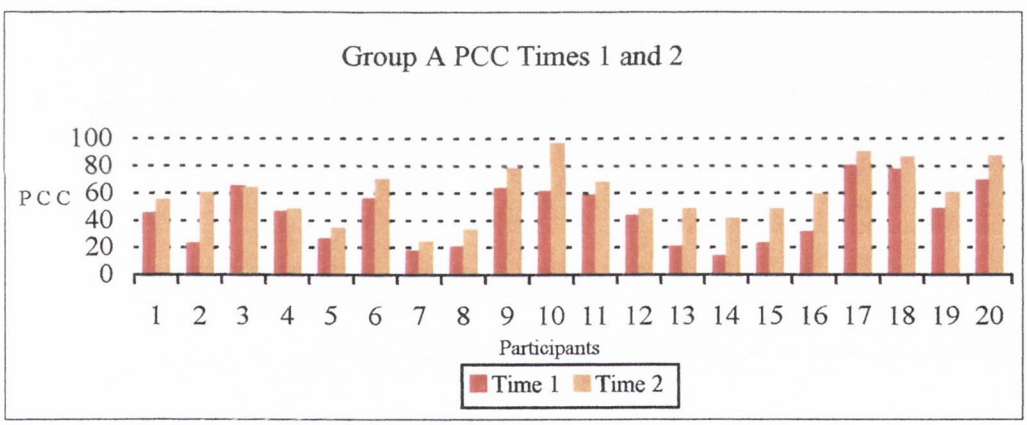


Figure: 6.15: Group A: Times 1 and 2: PCC

Participants 2, 10, 13, 14, 15 and 16 showed the greatest increases in PCC between time 1 and 2. Analysis of the individual profiles of these participants indicated that intelligibility ratings had increased for participant 2 by 3 points, participant 13 by 2 and for participant 16 by 1.

Consonants correct: Group A: Time 2-3

There were significant changes in percentage of consonants correct and consonant correct ratings in group A at time 3. Figure 6.16 illustrates the changes in individual PCC scores.

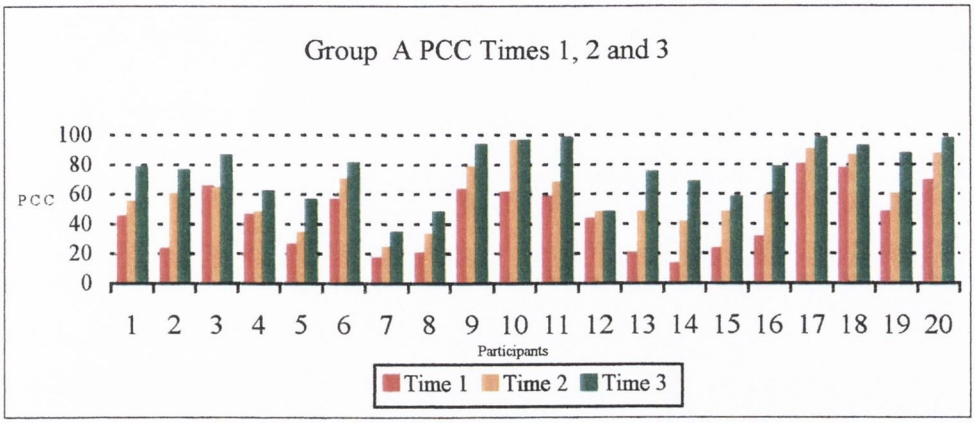


Figure: 6.16: Group A: Times 1, 2 and 3: PCC

The median score increased from 5.95 to 7.8 between times 2 and 3. Changes were evident in consonants correct tested as significant at $p \leq 0.0001$. One participant failed to show any change on PCC scores between times 2 and 3 (no. 10).

Consonants correct Group B: Time 1-2

Consonants correct ratings increased from a median score of 4.6 to 8.45 which tested as significant with $P \leq 0.0001$ (M. dif. -3.65: n=20).

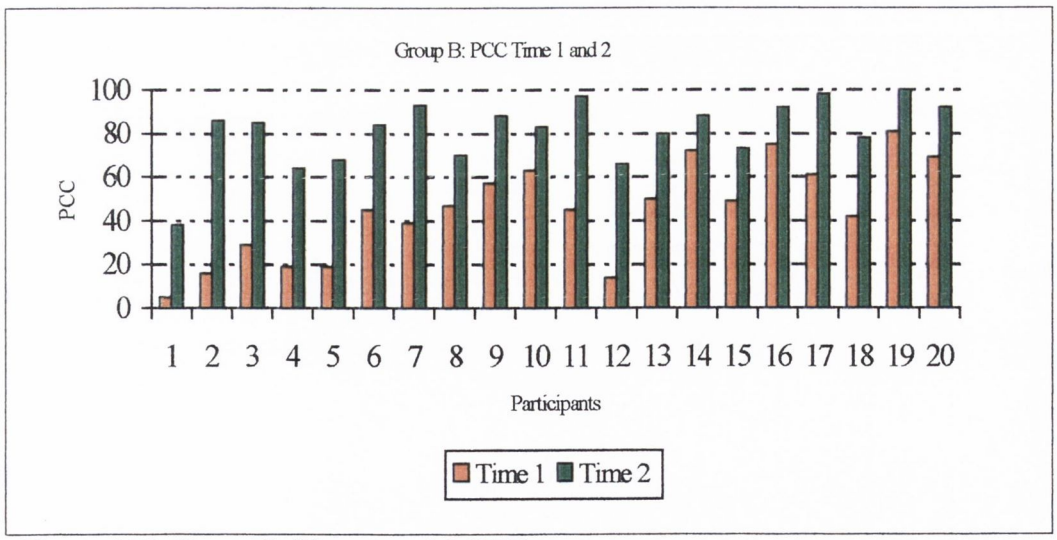


Figure 6.17: Group B: Time 1 and 2: PCC

All participants in group B showed increases on percentage of consonants correct scores as shown in figure 6.17.

Consonants correct: Summary

Median scores in group A increases from 4.55 at time 1, to 5.95 at time 2, to 7.85 at time 3. Group B scores increased from 4.6 at time 1 to 8.45 at time 2 (figure 6.18).

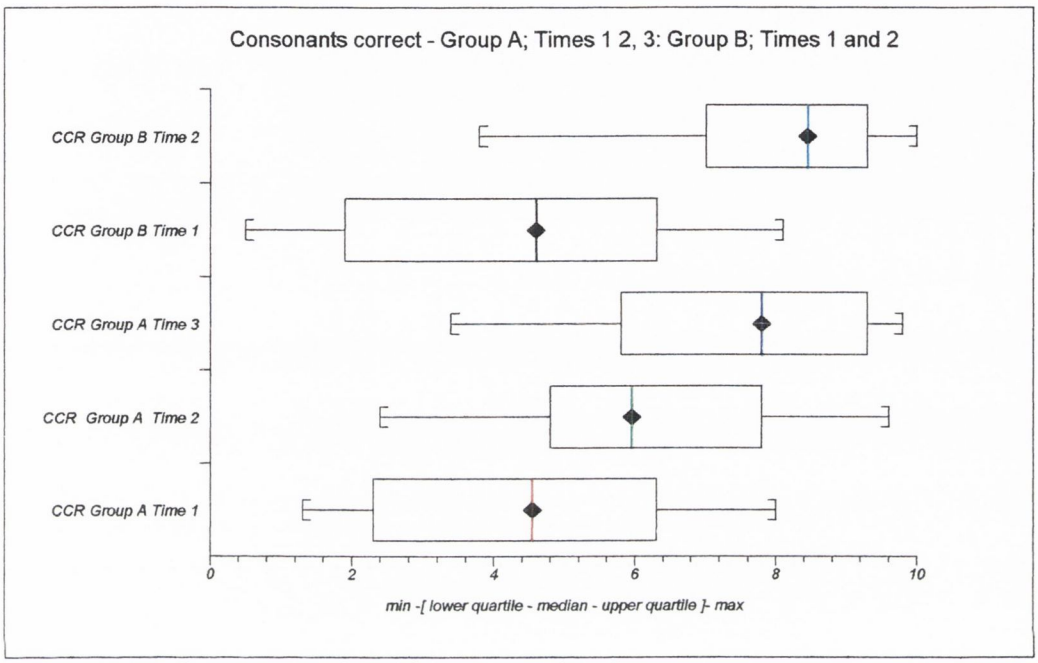


Figure 6.18: Groups A and B: Time 1, 2 and 3: Consonants correct

Both groups showed significant increases at all times in consonant correct ratings.

6.12.ii. Process number rating

Process number rating: Group A: Time 1 –2

Process number showed an increase between time 1 and 2 with a change in median scores from 7.5 to 10. This increase was not statistically significant when converted to process number rating and tested with the Wilcoxon (table 6.19).

Process number rating: Group A: Time 2 –3

The number of processes suppressed had increased in group A participants by time 3. Comparison of process number ratings scores tested as significant at p=0.0004 (Med. dif -1.5; n=20).

Process number rating: Group B: Time 1-2

There was a significant change in process number ratings between time 1 and 2.

Process number: Summary

Statistically significant differences were found between the number of processes and process number ratings pre and post therapy. The pattern of change in group A (illustrated in figure 6.19) suggests that this measure was not ecologically valid.

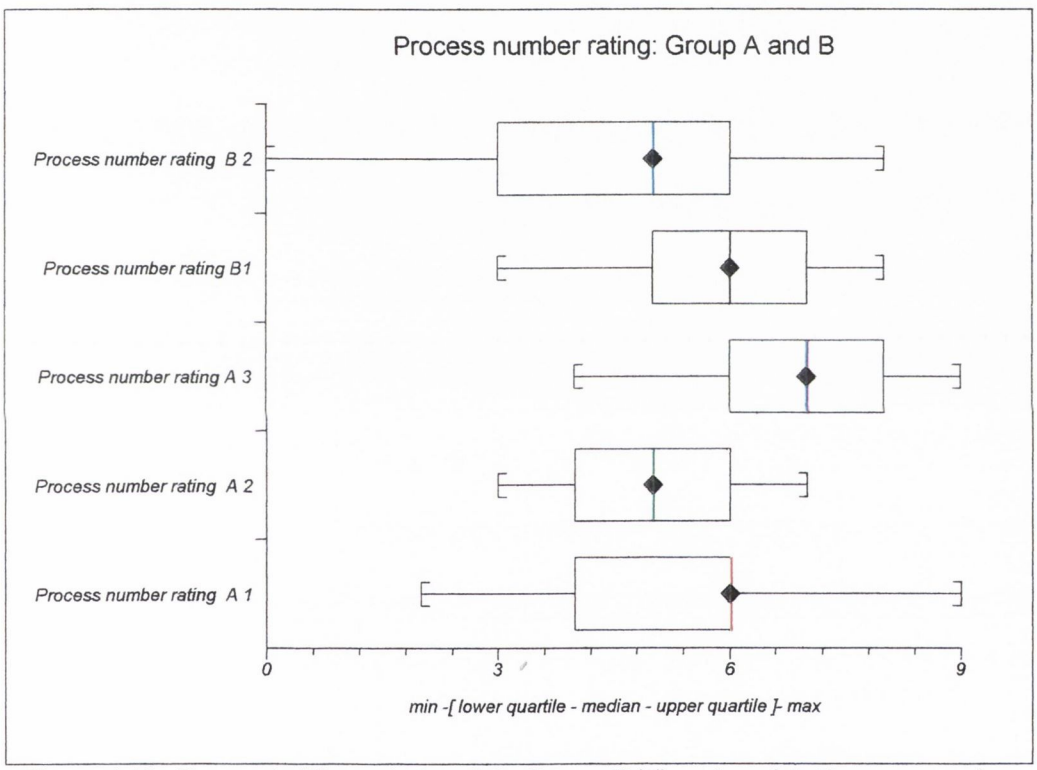


Figure 6.19: Group A: Times 1, 2 and 3: Group B Time 1 and 2: Process number rating

The number of processes present proved to be an unstable measure of change as it failed to allow for increases in place and manner processes as structural processes were suppressed. This can be seen in patterns of change in median scores on the rating scale with group A median of 7 at time 1; 5 at time 2 and 6 at time 3. Group B showed a change in median scores from 6 to 7.

6.12.iii. Process type

Group A Process type: Time 1 –2

There were no changes in the median scores for the number of process of types between time 1 and 2.

Process type: Group A: Time 2 –3

All process types showed a decrease in number by time 3.

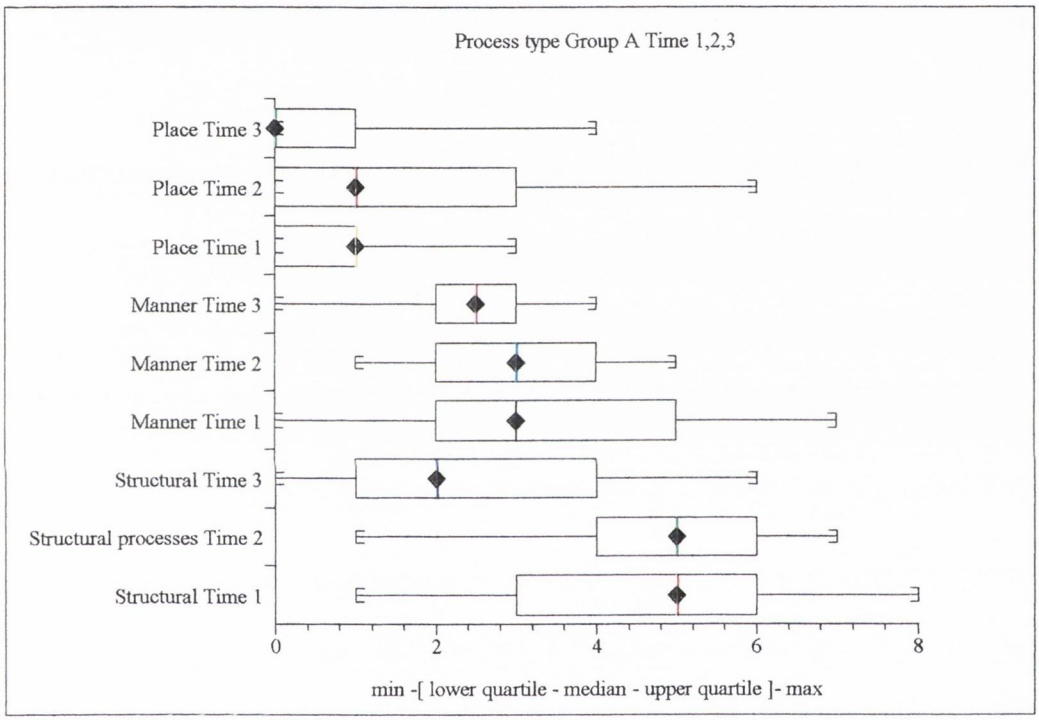


Figure 6.20: Group A Times 1, 2 and 3: Process type

Decreases in the number of structural and manner processes and an increase in place processes at Time 2 were not statistically significant. Changes in the number of structural and place processes were significant between Time 2 and 3. The number of manner processes showed a non significant reduction.

Process type: Group B Time 1 –2

Structural processes showed a significant difference between time 1 and 2. Place and manner processes showed no significant change (figure 6.21).

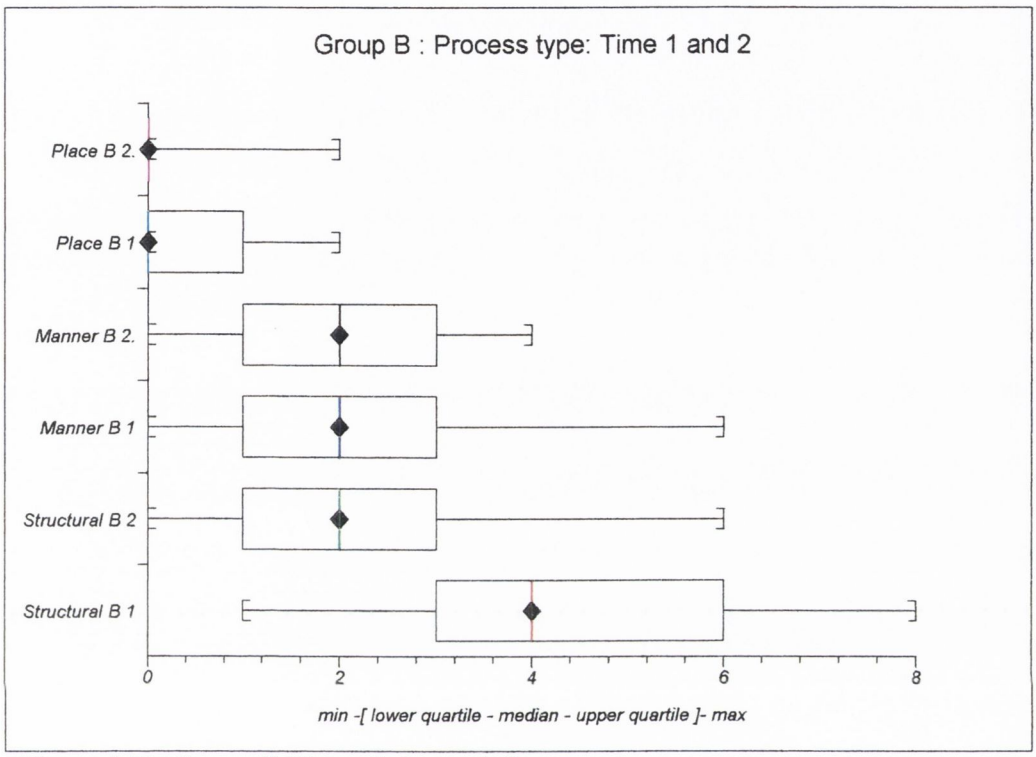


Figure 6.21: Group B Times 1, 2 and 3: Process type

Process type: Summary

Both groups showed significant decreases in structural processes. In group A this decrease was accompanied by a non statistically significant increase in the number of place processes.

6.12.iv. Process strength

Process strength: Group A: Time 1-2

There was no significant change in process strength rating between time 1 and 2.

Process strength: Group A: Time 2 –3

Process strength decreased from a median score of 2 at time 2 to 5.5 at time 3. Significant differences emerged between times 2 and 3.

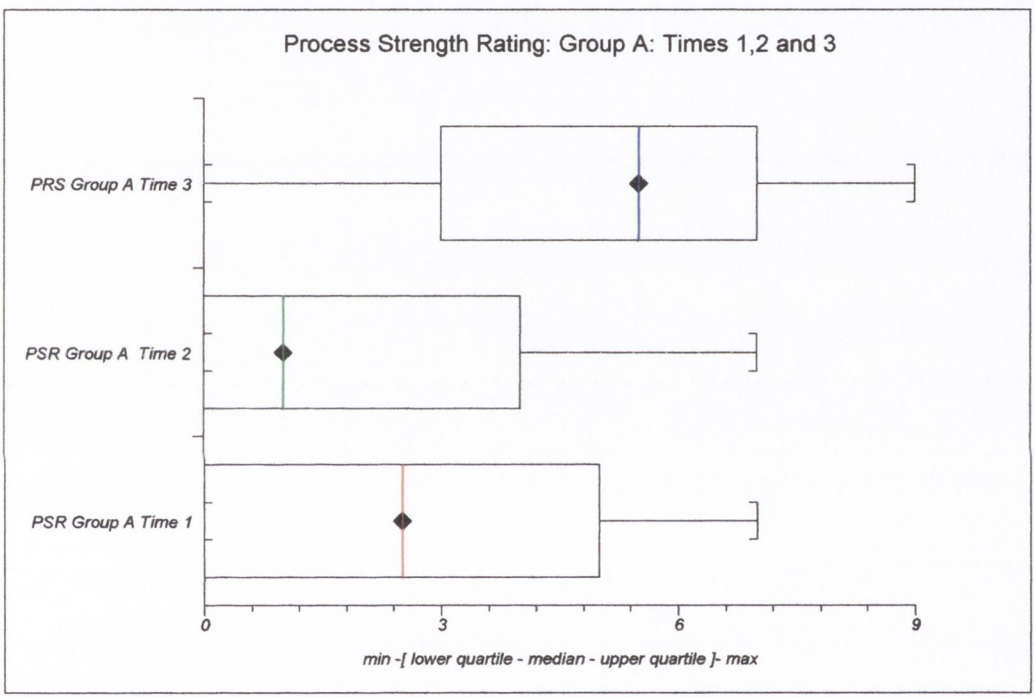


Figure 6. 22: Group A: Time 1, 2 and 3: Process strength

Process strength: Group B Time 1 –2

Process strength decreased in group B from a median score of 15 at time 1 to 6 at time 2. Comparison of strength rating at the two points indicated a median difference of 8.5, significant at P ≤0.0001 (Wilcoxon n=20).

Process strength: Summary

The number of phonemes influenced by phonological processes had decreased significantly in both groups by time 3.

6.12.v. System rating

System rating: Group A: Time 1-2

Comparison within the groups indicated a median difference of 1 on system ratings between times 1 and 2 (Wilcoxon p=0.0002: n=20). Changes occurred in 65 % of individual ratings (13 participants) during this period. The constraints reranked are marked in bold in column 1 of table 6.20.

System rating: Group A: Times 2-3

All participants showed changes in ratings between times 2 and 3 as illustrated in figure 6.23. Differences tested as significant (Wilcoxon P ≤0.0001 n=20).

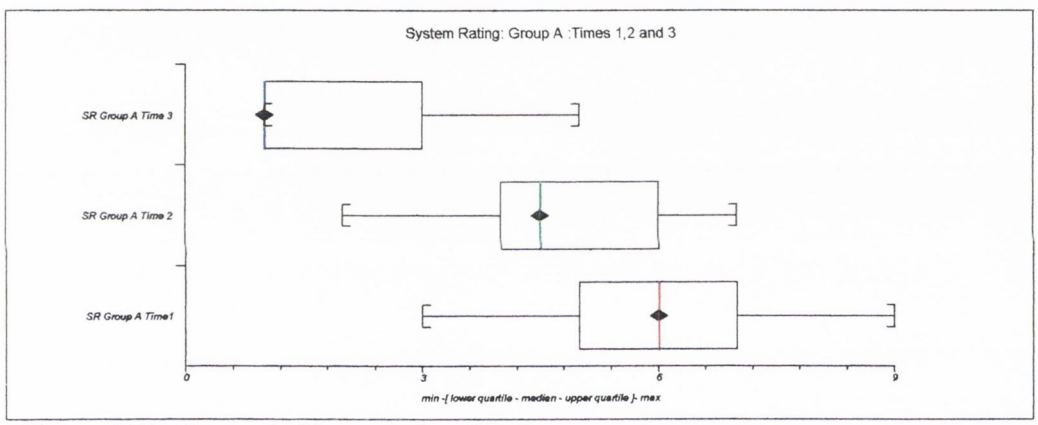


Figure 6.23: Group A: Times 1, 2 and 3: System rating

Individual profiles are illustrated in figure 6.24. These were analysed to identify patterns of change with results summarised in table 6.20.

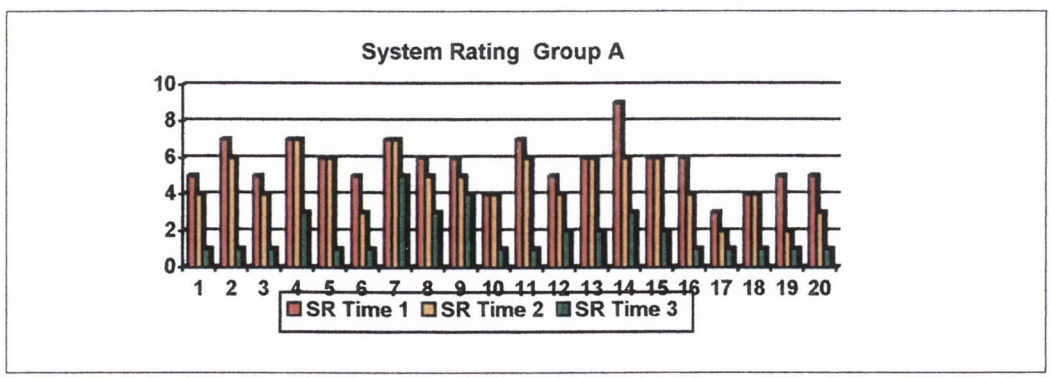


Figure 6.24: Group A: Times 1, 2 and 3: Changes in system ratings

Table 6.20: System Ratings: Individual changes Group A: Times 1, 2 and 3

Participant	Time 1 Constraints	SR 1	Time 2 Constraints	SR 2	SR 3	Dif	**Reranked Time 2-3**	Time 3 Constraints (Comments on patterns)
1.	*Coda plosive *Complex s *Complex o ***Fricative** *Liquid	5	*Coda plosive *Complex s *Complex o *Liquid	4	1	3	**Coda plosive** ***Complex s** ***Liquid**	*Complex o
2.	*Coda plosive *Coda fricative ***Coda other** *Coronal *Complex s *Complex o *Liquid	7	*Coda plosive *Coda fricative *Coda other *Coronal fricative *Complex s *Liquid	6	1	5	***Coda plosive** ***Coda fricative** ***Coda other** ***Coronal fricative** ***Complex s** ***Liquid**	Articulation (Deaffrication within words /ɹ/<->/l/ inconsistent in clusters)
3.	*Coda plosive *Coda fricative *Complex s *Complex o ***Liquid**	6	*Coda plosive *Coda fricative *Complex s *Complex o	4	1	3	***Coda plosive** ***Coda fricative** ***Complex s** ***Complex o**	Inconsistent (Inconsistent /s ɹ/ in clusters)
4.	*Coda plosive *Coda fricative *Coda other *Coronal Fricative *Complex s *Complex o	7	*Coda plosive *Coda fricative *Coda other *Coronal Fricative *Complex s *Complex o	7	3	4	***Coda plosive** ***Coda fricative** ***Coronal Fricative** ***Complex o**	*Coda other *Complex s Articulation (Articulation – lateral release all fricatives syllable final)
5.	*Coda plosive *Coda fricative *Coda other *Fricative *Complex s *Complex o	6	*Coda plosive *Coda fricative *Coda other *Fricative *Complex s *Complex o	6	1	5	***Coda plosive** ***Coda fricative** ***Coda other** ***Fricative** ***Complex s** ***Complex o**	Articulation (Lateralisation inconsistent /s z ʃ tʃ dʒ /)
6.	*Coda plosive ***Coda fricative** ***Coda other** *Complex s *Complex o	5	*Coda plosive *Complex s *Complex o	3	1	2	***Coda plosive** ***Complex s** ***Complex o**	Articulation (Inconsistent lateral release / ʃ tʃ dʒ/ in all syllables positions)
7.	*Coda	7	*Coda	7	5	2	***Coda**	*Coda plosive

	plosive *Coda fricative *Coda other *Fricative *Complex s *Complex o *Liquid		plosive *Coda fricative *Coda other *Fricative *Complex s *Complex o *Liquid				**fricative** ***Fricative**	*Coda other *Complex s *Complex o *Liquid
8.	*Coda plosive ***Coda fricative** *coda other *Dorsal *Complex s *Complex o	6	*Coda plosive *Coda other *Dorsal *Complex s *Complex o	5	3	2	***Coda plosive** ***Coda other** ***Dorsal**	*Complex s *Complex o Articulation Inconsistent (Time 1: No nasals Assimilation +)
9.	*Coda plosive *Coda fricative ***Coronal** *Complex s *Complex o *Liquid	6	*Coda plosive *Coda fricative *Complex s *Complex o *Liquid	5	4	1	***Coda plosive** ***Coda fricative**	*Complex s *Complex o *Liquid Articulation Inconsistent (No coronals time 1 Inconsistent time 3)
10.	*Coda plosive *Coda fricative *Complex s *Liquid	4	*Coda plosive *Coda fricative *Complex s *Liquid	4	1	3		Residual (deaffriction inconsistent)
11.	*Coda plosive *Coda fricative ***Coda other** *Dorsal *Complex s *Complex o *Liquid	7	*Coda plosive *Coda fricative *Dorsal *Complex s *Complex o *Liquid	6	1	5	***Coda plosive** ***Coda fricative** ***Dorsal** ***Complex s** ***Complex o** ***Liquid**	Articulation Inconsistent (Inconsistent /ɹ/ > / l / in clusters)
12.	*Coda plosive *Coda other ***Coronal** *Complex s *Complex o	5	*Coda plosive *Coda other *Complex s *Complex o	4	2	2	***Coda plosive** ***Complex o**	*Coda other *Complex s (Lateral friction /s z ʃ/)
13.	*Coda fricative *Coda plosive *Coda other *Coronal *Complex s *Complex o	6	*Coda fricative *Coda plosive *Coda other *Coronal *Complex s *Complex o	6	2	4	***Coda fricative** ***Coda other** ***Coronal** ***Complex s** ***Complex o**	*Coda plosive Articulation (Residual /ɹ/ > /w / clusters Time 1 Cor > Glottal Time 2 Cor > dorsal / Glottal Time 3 Lateral

								release coronal fricatives)
14.	*Coda fricative *Coda plosive ***Coda other** *Coronal ***Fricative** *Complex s *Complex o *Liquids ***Artic Prec**	9	*Coda fricative *Coda plosive *Coronal *Complex s *Complex o *Liquids	6	3	3	***Coda plosive** ***Complex s**	*Complex s *Coda plosive Articulation (Inconsistent fricative release Lateral/central Weak plosives Deaspiration)
15.	*Coda fricative *Coda plosive *Dorsal *Complex s *Complex o *Liquids	6	*Coda fricative *Coda plosive *Dorsal *Complex s *Complex o *Liquids	6	2	4	***Complex s**	No complex s Articulation (Residual gliding)
16.	***Coda fricative** *Coda other ***Coronal** *Complex s *Complex o *Liquid	6	*Coda other *Complex s *Complex o *Liquid	4	1	3		Articulation (Lateral release in sl sm sn sw clusters and /s z / within words)
17.	*Complex s ***Complex o** *Liquids	3	*Liquids *Complex s	2	1	1	***Liquids** ***Complex s (Lateral release in /s/ clusters)**	Articulation
18.	*Coda fricative *Complex s *Complex o *Liquids	4	*Coda fricative *Complex s *Complex o *Liquids	4	1	3	***Coda fricative** ***Complex s** ***Complex o** ***Liquids**	Residual (/ɹ/ > /w j / clusters)
19.	***Coda fricative** *Coda plosives ***Complex s** *Complex o ***Liquids**	5	*Coda plosives Articulation	2	1	1	***Coda plosives** **(Liberalisation /s z ʃ/)**	Articulation
20.	*Coda plosive ***Coda fricative** ***Coda other** *Complex s *Liquid	5	*Coda plosive *Complex s *Liquid	3	1	2	***Coda plosive** ***Complex s** ***Liquid**	Articulation Inconsistent (Inconsistent clusters liquids)

System rating: Group B: Time 1-2

All participants showed changes in ratings between times 1 and 2 as illustrated in figure 6.24. Differences tested as significant with P ≤0.0001 (Wilcoxon: Med. dif. 3.5 n=20).

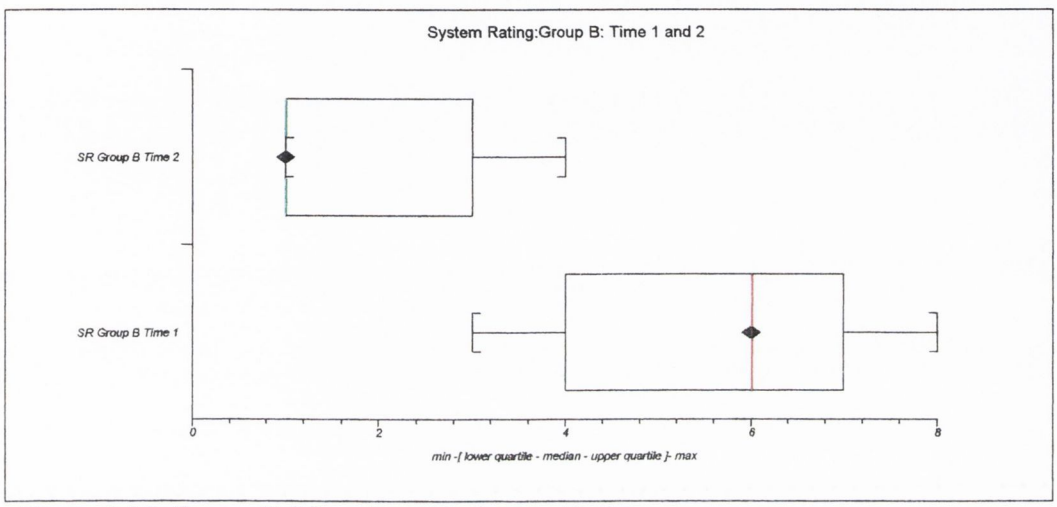


Figure 6.25: Group B: Time 1 and 2: System Rating

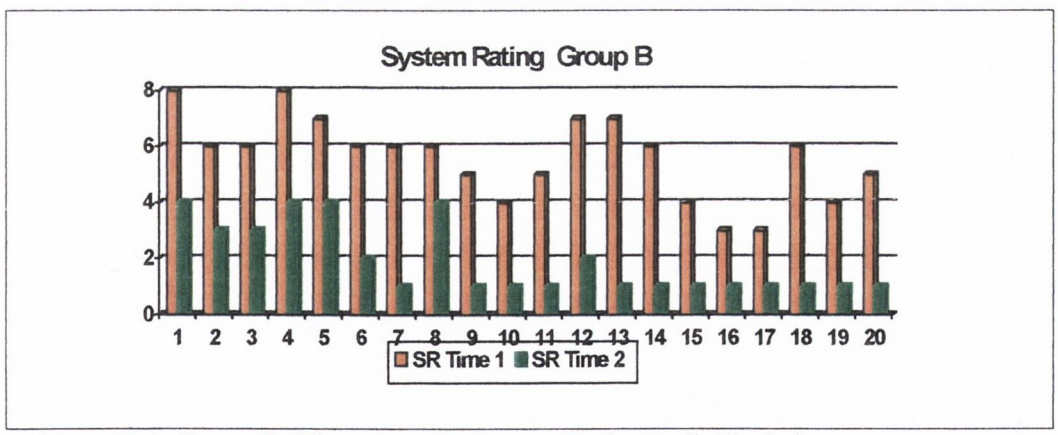


Figure 6.26: Group B: Time 1 and 2: System Rating Individual changes

Individual profiles are illustrated in figure 6.26 and rerankings summarised in table 6.21.

Table 6.21: Group B: Time 1 and 2: System Ratings: Individual changes

Part-icipant	Time 1 Constraints	SR1	SR2	Dif.	Reranked	Time 2 Constraints
1.	*Coda plosive *Coda fricative *Coda other *Fricative *Dorsal *Complex s *Complex o *Liquid	8	4	4	*Coda plosive *Coda fricative *Coda other *Fricative	*Dorsal *Complex s *Complex o (Inconsistent nasalisation / denasalisation)
2.	*Coda plosive *Coda fricative *Complex s *Complex o *Liquid ***Artic Prec**	6	3	3	*Coda plosive *Coda fricative *Complex o	*Complex s *Liquid Articulation (Inconsistent lateral release of fricatives and affricates)
3.	*Coda plosive *Coda fricative *Coda other *Complex s *Complex o *Liquid	6	3	3	*Coda plosive *Coda fricative *Coda other	*Complex s *Complex o Articulation (Lateral friction /ʃ tʃ dʒ/)
4.	*Coda plosive *Coda fricative *Coda other * Fricative *Complex s *Complex o *Liquid **8Artic Prec**	8	4	4	*Coda plosive *Complex s *Complex o *Liquid	*Coda plosive *Complex s *Complex o *Liquid
5.	*Coda fricative *Coda plosive *Coda other *Fricative *Complex s *Complex o *Liquid	7	4	3	*Coda plosive *Coda other *Fricative	*Coda plosive *Complex s *Complex o Inconsistent
6.	*Coda fricative *Coda plosive *Coda other *Complex s *complex o *Liquid	6	2	4	*Coda plosive *Liquid	*Coda plosive *Liquid (Assimilation in multi word utterances)
7.	*Coda fricative *Coda plosive *Fricative *Complex s *Complex o *Liquid	6	1	5	*Coda fricative *Coda plosive *Fricative *Complex s *Complex o *Liquid	**8Artic Prec** Residual /ɹ/ > /w l / in clusters Inconsistent
8.	*Coda fricative *Coda plosive *Coda other *Complex s	6	4	2	*Coda plosive *Complex s *Complex o *Liquid	

	*Complex o *Liquid					
9.	*Coda fricative *Coronal *Complex s *Complex o *Liquid	5	1	4	*Coda fricative *Coronal *Complex s *Complex o *Liquid	Residual (Time 1 All fricatives > interdentally Time 2 residual /ɹ/ in clusters Weak fricatives)
10.	*Coda plosive *Coda fricative *Complex s *Complex o	4	1	3	*Coda plosive *Coda fricative *Complex s *Complex o	**8Artic Prec** Lateralisation of /s ʃ tʃ/
11.	*Coda fricative *Coda plosive *Fricative *Complex s *Complex o	5	1	4	*Coda fricative *Coda plosive *Fricative *Complex s *Complex o	Articulation Inconsistent Final plosives and fricatives
12.	*Coda fricative *Coda plosive *Coda other *Fricative *Complex s *Complex o *Liquid	7	2	5	*Coda fricative *Coda plosive *Coda other *Fricative *Liquid	*Complex s *Complex o
13.	*Coda fricative *Coda plosive *Coda other *Complex s *Complex o *Liquid Articulation	7	1	6	*Coda fricative *Coda plosive *Coda other *Complex s *Complex o *Liquid	Articulation Residual (Time 1 Articulation nasalisation /s ʃ tʃ/ Time 2 residual /ɹ/ inconsistent)
14.	*Coda plosive *Coda fricative *Coronal fricative *Complex s *Complex o *Liquid	6	1	5	*Coda plosive *Coda fricative *Coronal fricative *Complex o *Liquid	*Complex s (Time 1 *Coronal only evident in fricatives)
15.	*Coda fricatives *Complex s *Complex o *Liquid	4	1	3	*Coda fricatives *Complex s *Complex o *Liquid	Articulation Time 1 All fricatives nasalized Time 2 Syllable initial /s z ʃ/ only
16.	*Complex s *Complex o *Dorsal	3	1	2	*Complex s *Complex o *Dorsal	Residual /ɹ/ > /w / clusters
17.	*Coda plosive *Coda other *Liquid	3	1	2	*Coda plosive *Coda other *Liquid	Articulation Inconsistent
18.	*Coda plosive *Coda fricative *Coda other	6	1	5	*Coda plosive *Coda fricative *Coda other	Articulation Inconsistent voicing/devoicing

	*Coronal fricative *Complex s *Complex o *Liquid				*Coronal fricative *Complex s *Complex o *Liquid	fricatives Deaffrication /tʃ/ >/tj/
19.	*Complex s *Complex o *Liquid	4	1	3	*Complex s *complex o *Liquid	Residual (Time 1 Oral Structural difficulties Time 2 lateral release syllable final s z)
20.	*Coda plosive *Coda other *Complex s *Complex o *Liquid	5	1	4	*Coda plosive *Coda other *Complex s *Complex o *Liquid	Articulation (Inconsistent /ɹ/ > /w j l / clusters and syllable initial Clusters)

System rating: Summary

Analysis of system ratings showed significant changes at all time points. Group A changes between times 1 and 2 suggested that participants were moving towards typical developmental pathways during this period with the ban on coronal constraints reduced and the constraint on codas restricted.

Changes in system ratings post therapy group A time 3, group B time 2, indicated accelerated reranking relative to changes in the pre therapy period. Rapid promotion of syllable and word faithfulness constraints above markedness constraints occurred. All indicated a move towards the target language rankings of the selected constraints. Speech patterns at time 3 showed errors, which appeared to have an articulatory basis. These included lateral release of friction on coronals and inconsistent gliding of liquids in clusters.

Summary: Changes in intelligibility and in the phonological system

Participants in group A showed gains in consonants correct and in system ratings in the indirect intervention period. These changes did not result in changes in speech intelligibility ratings or the number of developmental processes.

The accelerated change in intelligibility which occurred during the therapy period in both groups was reflected in changes in all measures of the phonological system.

6.13. Changes in phonological systems and in other components of language

Group A: Time 1 and 2: Changes in speech and language measures

Significant changes were evident in all language measures in group A when ratings from time 1 and 2, were compared and tested with the Wilcoxon signed ranks test (Table 6.22).

Table 6.22 Group A: Time 1 and 2: Changes in speech and language measures

Group A (n=20)	Time 1		Time 2		Wilcoxon signed ranks		
	Mean	Med.	Mean	Med	M Dif.	p	
Language rating	**2.15**	**2**	**2.6**	**2**	**- 0.5**	**0.0195**	*
Receptive vocabulary	**0.85**	**0**	**1.55**	**2**	**-0.5**	**0.0156**	*
Expressive vocabulary	**1.7**	**1**	**3.05**	**3**	**-1.5**	**0.0134**	*
Receptive morphology	**0.5**	**0**	**1.6**	**1**	**-1**	**0.0085**	**
Expressive morphology	**1**	**0**	**2.5**	**2**	**-1**	**0.0105**	*
Receptive syntax	**0.55**	**0**	**1.3**	**1**	**-1**	**0.0295**	*
Expressive syntax	**1.15**	**0**	**2.85**	**3**	**-1.5**	**0.0013**	**

Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group A: Time 2 and 3: Changes in speech and language measures

Median scores showed gains in all areas except receptive syntax as summarised on table 6.23. Evaluation using the Wilcoxon signed ranks indicated significant changes in receptive vocabulary, expressive vocabulary, expressive morphology and expressive syntax.

Table 6.23: Group A: Time 2 and 3: Language measures

Group A (n=20)	Time 2		Time 3		Wilcoxon		
	Mean	Median	Mean	Median	MDif.	p	
Language rating	2.6	2	3.95	4	**-1.5**	**<0.0001**	***
Receptive vocabulary	1.55	2	2.65	2	**-1**	**0.0002**	***
Expressive vocabulary	3.05	3	4.15	4.5	**-1**	**0.001**	***
Receptive morphology	1.6	1	2.5	2	- 0.5	0.1353	ns
Expressive morphology	2.5	2	4.2	4	**-1.5**	**0.0034**	**
Receptive syntax	1.3	1	2.2	1	- 0.5	0.2114	ns
Expressive syntax	2.85	3	4.45	3.5	**-1.5**	**0.0006**	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group B: Time 1 and 2: Changes in speech and language measures

Group B showed significant change in all language measures when time 1 and time 2 scores were compared and tested using the Wilcoxon (table 6.24).

Table 6.24: Group B: Time 1 and 2: Language measures

Group B (n=20)	Time 1		Time 2		Wilcoxon		
	Mean	Median	Mean	Median	Med.	p	
Language rating	3.95	4	5.35	6	**1.5**	**0.0002**	***
Receptive vocabulary	2.25	2	2.9	3	**-1**	**0.0134**	*
Expressive vocabulary	3.95	3.5	5.25	5	**-1**	**0.0295**	*
Receptive morphology	1.35	1	2.8	2.5	**-1.5**	**0.0002**	***
Expressive morphology	1.95	1	5.25	5	**-3**	**<0.0001**	***
Receptive syntax	1.15	1	2.6	2	**1.5**	**0.0098**	**
Expressive syntax	2.85	3	5.6	5.5	**-2**	**<0.0001**	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Changes in the patterns of association between speech and general language levels and between speech measures and the selected components of language are explored in following sections.

Language ratings

Group A

Language ratings increased at all time points as illustrated by figure 6.27. Changes in language ratings were significant with time 2 $p \leq 0.05$ and time 3: $p < 0.0001$.

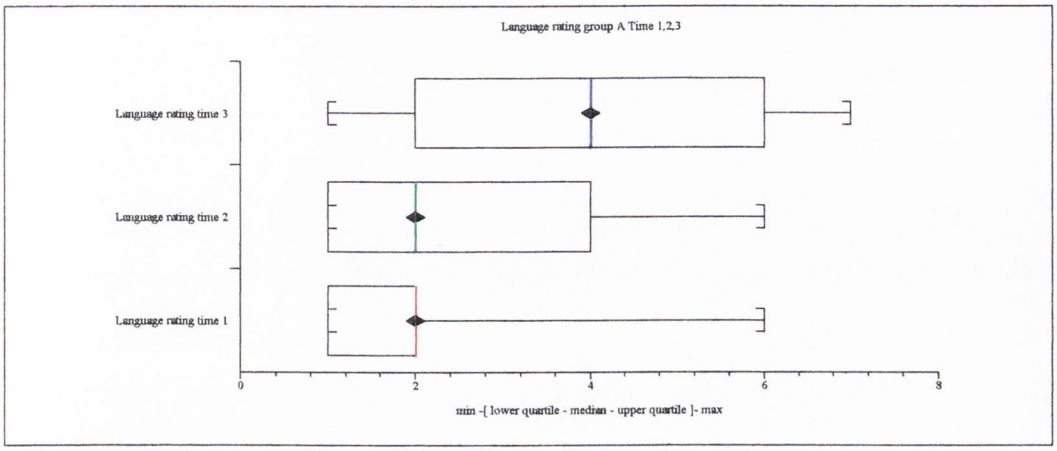


Figure 6.27: Group A: Times 1-2-3: Changes in language ratings

Group A: Times 1-2 Language ratings and speech measures

Patterns of association between general language skills and process measures were the same at time 1 and 2. The relationships between consonants correct and system rating and language increased in strength (table 6.25).

Table 6.25: Group A Time 1 and 2: Language and speech measures

Language rating	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	
Intelligibility	0.44	0.0524	ns	0.30	0.1948	ns
Consonant correct rating	**0.36**	**0.1201**	**ns**	**0.52**	**0.0193**	*
Process number rating	0.78	<0.0001	***	0.78	<0.0001	***
Process strength rating	0.51	0.0227	*	0.51	0.0236	*
System rating	**-0.43**	**0.0598**	**ns**	**-0.48**	**0.0333**	*

* Significant at .05 level; ** Significant at .01 level; ** *Significant at .001 level

Group A: Time 2 and 3: Language and speech measures

Comparison of correlations between language ratings and speech measures at time 2 and 3 indicted increasing strength in all relationships as summarised in table 6.26.

Table 6.26: Group A: Time 2 and 3: Language and speech measures

Language rating	Time 2			Time 3		
Spearman's r (n=20)	r	p		r	p	
Intelligibility	**0.30**	**0.1948**	**ns**	**0.76**	**0.0001**	***
Consonant correct rating	**0.52**	**0.0193**	*	**0.83**	**<0.0001**	***
Process number rating	0.78	<0.0001	***	0.82	<0.0001	***
Process strength rating	**0.51**	**0.0236**	*	**0.79**	**<0.0001**	***
System rating	**-0.48**	**0.0333**	*	**-0.62**	**0.0041**	**

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group B: Time 1 and 2: Language and speech measures

The relationship between intelligibility, process number, process strength and language had weakened in Group B at time 2. The positive relationships with consonants correct and the negative relationship with system rating strengthened (table 6.27).

Table 6.27: Group B: Time 1 and 2: Language and speech measures

Language	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	
Intelligibility	**0.81**	**< 0.0001**	***	**0.41**	**0.0712**	**ns**
Consonant correct rating	**0.62**	**0.0041**	**	**0.69**	**0.001**	***
Process number rating	**0.47**	**0.0384**	*	**0.35**	**0.1268**	**ns**
Process strength rating	**-0.60**	**0.0056**	**	**0.49**	**0.0309**	*
System rating	**-0.57**	**0.0101**	*	**-0.78**	**<0.0001**	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Receptive vocabulary and speech measures

Group A: Time 1 and 2: receptive vocabulary

Positive correlations between receptive vocabulary and consonants correct and receptive vocabulary and process strength decreased in strength between times 1 and 2. Correlations between system ratings and receptive vocabulary increased in strength (table 6.28).

Table 6.28: Group A: Time 1 and 2: Receptive vocabulary and speech measures

Receptive vocabulary	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	
Intelligibility	0.39	0.0933	ns	0.14	0.5551	ns
Consonant correct rating	**0.59**	**0.0074**	**	**0.47**	**0.0378**	*
Process number rating	0.62	0.0043	**	0.58	0.0078	**
Process strength rating	**0.60**	**0.0058**	**	**0.49**	**0.0281**	*
System rating	**-0.45**	**0.0474**	*	**-0.63**	**0.0036**	**

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Group A: Time 2 and 3: Receptive vocabulary and speech measures

Receptive vocabulary showed increasingly stronger relationships with all speech measures with the exception of system rating by Time 3 (table 6.29).

Table 6.29: Group A: Time 2 and 3: Receptive vocabulary and speech measures

Receptive vocabulary	Time 2			Time 3		
Spearman's r (n=20)	r	p		r	p	
Intelligibility	**0.14**	**0.5551**	**ns**	**0.45**	**0.0458**	*
Consonant correct rating	0.47	0.0378	*	0.50	0.0261	*
Process number rating	0.58	0.0078	**	0.65	0.0023	**
Process strength rating	**0.49**	**0.0281**	*	**0.66**	**0.002**	**
System rating	**-0.63**	**0.0036**	**	**-0.23**	**0.3212**	**ns**

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group B: Time 1 and 2 Receptive vocabulary and speech measures

Group B showed a stronger negative relationship between receptive vocabulary and system rating at time 2, relationships with all other speech measures had decreased in strength (table 6.30)

Table 6.30: Group B: Time 1 and 2: Receptive vocabulary and speech measures

Receptive vocabulary	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	
Intelligibility	**0.56**	**0.0116**	*	**0.05**	**0.8313**	**ns**
Consonant correct rating	0.42	0.0617	ns	0.33	0.1504	ns
Process number rating	**0.50**	**0.0261**	*	**0.08**	**0.7191**	**ns**
Process strength rating	0.36	0.1201	ns	0.26	0.2725	ns
System rating	**-0.54**	**0.0157**	*	**-0.64**	**0.0027**	**

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Expressive vocabulary

Group A: Time 1 and 2: Expressive vocabulary and speech measures

Relationships between expressive vocabulary and intelligibility, consonants correct, and system rating increased in strength from time 1 to 2. Correlations between expressive vocabulary and process number decreased in strength (table 6.31).

Table 6.31: Group A: Time 1-2: Expressive vocabulary and speech measures

Expressive vocabulary	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	**0.22**	**0.3474**	**ns**	**0.75**	**0.0002**	*******
Consonant correct rating	**0.44**	**0.0507**	**ns**	**0. 57**	**0.009**	******
Process number rating	**0.71**	**0.0007**	*******	**0.61**	**0.0052**	******
Process strength rating	0.60	0.0061	**	0.60	0.0058	**
System rating	**-0.27**	**0.2528**	**ns**	**-0.67**	**0.0015**	******

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group A: Time 2 and 3: Expressive vocabulary and speech measures

Relationships between expressive vocabulary and all speech measures increased in strength by time 3 (table 6.32).

Table 6.32: Group A: Time 2-3: Expressive vocabulary and speech measures

Expressive vocabulary	Time 2			Time 3		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	0.75	0.0002	***	0.77	<0.0001	***
Consonant correct rating	**0. 57**	**0.009**	******	**0.85**	**<0.0001**	*******
Process number rating	**0.61**	**0.0052**	******	**0.76**	**0.0001**	*******
Process strength rating	**0.60**	**0.0058**	**ns**	**0.78**	**<0.0001**	*******
System rating	**-0.67**	**0.0015**	******	**-0.72**	**0.0004**	*******

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group B: Time 1 and 2: Expressive vocabulary and speech measures

Relationships between consonants correct, system rating and expressive vocabulary increased in strength from time 1 to 2. Correlations between expressive vocabulary and process measures decreased in strength (table 6.33). Relationship between expressive vocabulary and system rating increased significantly in strength.

Table 6.33: Group B: Time 1 and 2: Expressive vocabulary and speech measures

Expressive vocabulary	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	0.33	0.1504	ns	0.23	0.3244	ns
Consonant correct rating	**0.46**	**0.0398**	*****	**0.64**	**0.0029**	******
Process number rating	**0.56**	**0.0118**	*****	**0.23**	**0.3244**	**ns**
Process strength rating	0.40	0.0841	*	0.48	0.0321	*
System rating	**-0.28**	**0.2238**	**ns**	**-0.80**	**<0.0001**	*******

* Significant at .05 level; ** Significant at .01 level; ** *Significant at .001 level

Receptive morphology and speech measures

Group A: Time 1 and 2: Receptive morphology and speech measures

Receptive morphology showed weak correlations with intelligibility, consonants correct and system rating at time 1. These relationships had strengthened by time 2. Relationships with process measures, which were significant at time 1 had weakened by time 2 (table 6.34).

Table 6.34 Group A: Time 1 and 2: Receptive morphology and speech measures

Receptive morphology	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	**0.08**	**0.7239**	**ns**	**0.54**	**0.0144**	*****
Consonant correct rating	**0.36**	**0.1122**	**ns**	**0.56**	**0.0116**	*****
Process number rating	**0.65**	**0.0025**	******	**0.40**	**0.0841**	**ns**
Process strength rating	**0.54**	**0.0154**	*****	**0.41**	**0.0768**	**ns**
System rating	**-0.16**	**0.5005**	**ns**	**-0.73**	**0.0004**	*******

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group A: Times 2- 3 Receptive morphology and speech measures

Relationships between receptive morphology and intelligibility decreased in strength by Time 3. System rating showed a similar pattern while correlations with process measures increased (table 6.35).

Table 6.35: Group A: Time 2 and 3: Receptive morphology and speech measures

Receptive morphology	Time 2			Time 3		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	**0.54**	**0.0144**	*****	**0.33**	**0.1504**	**ns**
Consonant correct rating	0.56	0.0116	*	0.56	0.0118	*
Process number rating	**0.40**	**0.0841**	**ns**	**0.45**	**0.0466**	*****
Process strength rating	**0.41**	**0.0768**	**ns**	**0.60**	**0.0062**	******
System rating	**-0.73**	**0.0004**	*******	**-0.20**	**0.4071**	**ns**

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Group B: Times 1-2: Receptive morphology and speech measures

Correlations between intelligibility, consonants correct, process number and receptive morphology decreased by time 2. Receptive morphology showed a significant relationship with system rating at time 2 (table 6.36).

Table 6.36: Group B: Time 1 and 2: Receptive morphology

Receptive morphology	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	0.42	0.0648	ns	0.21	0.3644	ns
Consonant correct rating	0.43	0.0588	ns	0.21	0.3678	ns
Process number rating	0.37	0.1091	ns	0.32	0.1663	ns
Process strength rating	0.24	0.3086	ns	0.43	0.0569	ns
System rating	**-0.13**	**0.5901**	**ns**	**-0.45**	**0.0474**	*****

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Expressive morphology and speech measures

Group A: Times 1-2 Expressive morphology and speech measures

Relationships between expressive morphology and process number ratings remained unchanged over time. Correlations between expressive morphology

and other speech measures, which were not significant at time 1, had all strengthened by time 2 (table 6.37).

Table 6.37. Group A: Time 1 and 2: Expressive morphology and speech measures

Expressive morphology	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	**0.02**	**0.9468**	**ns**	**0.66**	**0.0019**	******
Consonant correct rating	**0.26**	**0.2725**	**ns**	**0.65**	**0.0025**	*******
Process number rating	0.49	0.0298	*	0.49	0.028	*
Process strength rating	**0.42**	**0.0679**	**ns**	**0.46**	**0.045**	*****
System rating	**-0.11**	**0.6442**	**ns**	**-0.66**	**0.0019**	******

* Significant at .05 level; ** Significant at .01 level; ***Significant at .001 level

Group A: Time 2- 3: Expressive morphology and speech measures

Relationships between expressive morphology and intelligibility decreased in strength by time 3, while relationships with other speech measures remained static or increased in strength (table 6.38).

Table 6.38: Group A: Time 2 and 3: Expressive morphology and speech measures

Expressive morphology	Time 2			Time 3		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	**0.66**	**0.0019**	******	**0.54**	**0.0154**	*****
Consonant correct rating	0.65	0.0025	***	0.70	0.0007	***
Process number rating	**0.49**	**0.028**	*****	**0.64**	**0.0029**	******
Process strength rating	**0.46**	**0.045**	*****	**0.68**	**0.0014**	******
System rating	-0.66	0.0019	**	-0.66	0.0019	**

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group B: Time 1 and 2 Expressive morphology and speech measures

Expressive morphology showed significant correlations with intelligibility and consonants correct only at time 1. Correlation with intelligibility had weakened at time 2 while correlation with consonants correct showed a slight increase (table 6.39).

Table 6.39: Group B: Time 1 and 2: Expressive morphology and speech measures

Expressive morphology	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	**0.54**	**0.0147**	*****	**0.38**	**0.1017**	**ns**
Consonant correct rating	0.47	0.0384	*	0.5	0.0266	*
Process number rating	0.18	0.4486	ns	0.22	0.3407	ns
Process strength rating	0.30	0.1994	ns	0.40	0.0841	ns
System rating	-0.17	0.4682	ns	-0.44	0.0542	ns

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Receptive syntax

Group A: Time 1 and 2: Receptive syntax and speech measures

Receptive syntax showed significant correlation with process number only at time 1. By time 2, a significant correlation was found for system ratings only (table 6.40).

Table 6.40: Group A: Time 1 and 2: Receptive Syntax and speech measures

Receptive syntax	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	0.13	0.5945	ns	0.28	0.2213	ns
Consonant correct rating	0.14	0.5594	ns	0.40	0.0816	ns
Process number rating	**0.61**	**0.0054**	**	**0.26**	**0.2668**	**ns**
Process strength rating	0.30	0.2018	ns	0.22	0.3407	ns
System rating	**-0.20**	**0.3854**	**ns**	**-0.52**	**0.0201**	*

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group A: Times 2- 3 Receptive syntax and speech measures

Receptive syntax showed a significant relationship with system rating alone at time 2. This relationship was weaker by time 3. Consonant correct and process measures showed stronger correlations with receptive syntax at time 3 (table 6.41).

Table 6.41: Group A: Time 2 and 3: Receptive syntax and speech measures

Receptive syntax	Time 2			Time 3		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	0.28	0.2213	ns	0.43	0.0617	ns
Consonant correct rating	**0.40**	**0.0816**	**ns**	0.67	**0.0014**	**
Process number rating	**0.26**	**0.2668**	**ns**	0.62	**0.0046**	**
Process strength rating	**0.22**	**0.3407**	**ns**	0.75	**0.0002**	***
System rating	**-0.52**	**0.0201**	*	-0.33	0.1582	ns

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group B: Time 1 and 2: Receptive syntax and speech measures

Positive correlations between consonants correct, process measures and receptive syntax decreased by time 2. The negative relationship between receptive syntax and system rating increased (table 6.42).

Table 6.42: Group B: Time 1 and 2: Receptive syntax and speech measures

Receptive syntax	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	**0.48**	**0.0315**	*	**0.48**	**0.0327**	*
Consonant correct rating	**0.48**	**0.0315**	*	**0.28**	**0.2263**	ns
Process number rating	**0.51**	**0.0227**	*	**0.37**	**0.1061**	ns
Process strength rating	**0.53**	**0.0178**	ns	**0.52**	**0.0193**	*
System rating	**-0.27**	**0.2528**	ns	**-0.47**	**0.0364**	*

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Expressive syntax

Group A: Time 1 and 2: Expressive syntax and speech measures

Expressive syntax showed significant increases in positive and negative correlations with speech measures at time 2 (table 6.43).

Table 6.43: Group A: Time 1 and 2: Expressive syntax and speech measures

Expressive syntax	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	**0.03**	**0.8913**	ns	**0.75**	**0.0002**	***
Consonant correct rating	**0.24**	**0.3024**	ns	**0.67**	**0.0015**	**
Process number rating	**0.55**	**0.0124**	*	**0.63**	**0.0034**	**
Process strength rating	**0.40**	**0.078**	ns	**0.53**	**0.0164**	*
System rating	**-0.08**	**0.7239**	ns	**-0.76**	**0.0001**	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group A: Time 2 and 3: Expressive syntax and speech measures

Expressive syntax showed stronger relationships with consonants correct, process number, process strength and system rating at time 3. Correlations with intelligibility decreased by time 3 (table 6.44).

Table 6.44: Group A: Time 2 and 3: Expressive syntax and speech measures

Expressive syntax	Time 2			Time 3		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	**0.75**	**0.0002**	***	**0.62**	**0.0041**	**
Consonant correct rating	**0.67**	**0.0015**	**	**0.79**	**<0.0001**	***
Process number rating	**0.63**	**0.0034**	**	**0.59**	**0.0066**	**
Process strength rating	**0.53**	**0.0164**	*	**0.58**	**0.0078**	**
System rating	-0.76	0.0001	***	-0.81	< 0.0001	***

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Group B: Time 1 and 2 Expressive syntax and speech measures

Expressive syntax showed weak non significant correlations with all speech measures at time 1. Consonant correct ratings showed increased strength at time 2 (table 6.46).

Table 6.45: Group B: Time 1 and 2: Expressive syntax and speech measures

Expressive syntax	Time 1			Time 2		
Spearman's r (n=20)	r	p		r	p	r
Intelligibility	0.38	0.0988	ns	0.43	0.0569	ns
Consonant correct rating	0.38	0.0946	ns	**0.52**	**0.0193**	*
Process number rating	0.30	0.2041	ns	0.13	0.5768	ns
Process strength rating	0.24	0.3086	ns	0.37	0.1106	ns
System rating	-0.20	0.4034	ns	-0.42	0.0668	ns

* Significant at .05 level; ** Significant at .01 level; *** Significant at .001 level

Changes in phonological systems and language components: Summary

Participants in group A showed significant change in all measures of language during the period of indirect intervention (Time 1-2). The relationships between speech measures and components of the language system increased as the phonological system moved towards the target language system. This trend was accelerated following the intervention period for all language measures except receptive morphology and syntax. Participants in group B showed similar significant changes in all measures pre and post therapy.

6.14. Patterns of change in the phonological systems

Analysis of the data from both groups indicated that change followed typical developmental trends with

- Significant increases in intelligibility scores relative to language levels
- An increased match of consonants with the target system as reflected in significant increases in percentage of consonants correct scores
- Significant decreases in the number of phonological processes

- Significant reduction in process strength
- Significant decrease in structural processes
- Significant decreases in system ratings

CHAPTER 7

DISCUSSION

The findings from these studies indicated variations from the typical developmental pathways of speech as a carrier of language in the Down syndrome participant group. These variations were evident in both in time and manner reflecting findings of delays and differences reported in the literature. Findings from the three studies are presented separately in the following sections with overall conclusions presented in 7. 6. The findings of the first study indicated that discrepancies between speech intelligibility and language abilities were present from the early stages of development. The second study found significant associations between low speech intelligibility and the phonological system and tentative associations between phonology and other components of language. Findings from the third study indicated that gains in intelligibility following therapy were reflected in changes in the phonological systems and accompanied by changes in other components of language.

7.1. Study 1

Study 1 compared the speech intelligibility ratings and phonological development of a group of children and adults with Down syndrome to those of a group of typically developing children matched by language age. Significant differences were found between the groups in the intelligibility levels attained and in

phonological development as measured by consonants correct, phonological analysis and phonemic inventories.

7.1.2. Intelligibility and language levels

Comparison of speech intelligibility ratings indicated significant differences between the groups on levels of intelligibility achieved at all language ages. The intelligibility scores in the group with Down syndrome were lower at the base language age of two years and remained below the levels achieved by the typically developing group across the language age levels studied.

Variations in developmental rate and degree were evident with increasing language levels in both groups. The typically developing group showed rapid gains in intelligibility between the three and four year language level, as would be expected from the findings of developmental studies reported in the literature (Vihman et al., 1988; Weiss, 1982). This gain was not seen in the participants with Down syndrome. The developmental gain seen in this group was slower and spread over the full range of language levels. This may reflect specific phonological impairment or could be indicative of a deceleration in speech development noted in other studies of children with Down syndrome (Chapman et al., 1994; Smith & Stoel - Gammon, 1983).

The discrepancy between language levels and speech intelligibility is significant developmentally and clinically. Low speech intelligibility at the early stage of language development will reduce opportunities for the satisfactory verbal interactions with others which scaffold phonological learning. Parents and communication partners may reduce language input and adapt their speech to match the child's output and perceived competence level. The strategies used by communication partners to achieve effective interaction may result in a reduction in vocabulary thus reducing opportunities for the child to develop new vocabulary. Vocabulary size and word frequency have been associated with the development of categorisation and with the abstraction of the phonological rules

of the language system (Fenson et al., 1994, Levelt & Van der Vijver, 1998; Smolensky, 1996a). Reduction in input to language form may also apply to morphological and syntactic form as speakers frequently reduce, restrict or restructure form in order to maintain message transmission. Reductions in input may constrain the development of phoneme, word and syllable forms. Regression to syntactic, morphological and phonological unmarked forms by the speaker may reduce opportunities and motivation to develop phonological form in the learner.

Low speech intelligibility may reduce opportunities for specific feedback and responses from others which facilitate the learning of phonological form and repair strategies. Reductions in phonetically contingent responses have been reported in maternal responses to the vocalisations of infants with Down syndrome (Velleman, Mangipudi & Locke, 1989). It is difficult to provide contingent feedback when utterances are unintelligible. The provision of specific phonetic feedback fosters the development of articulatory repair strategies and metaphonological knowledge. Metaphonological skills and repair strategies have been associated with increasing intelligibility in children with phonological impairment (Howell & Dean, 1994). Repair strategies may be rendered unnecessary by dense social networks where utterances may be unintelligible by comparison with the ambient language code but are interpretable due to context and familiarity.

Physical, sensory, cognitive and social constraints may all contribute to a reduction in motivation to develop intelligible speech in infants and children with Down syndrome. The physical and sensory constraints outlined in chapters two and three will demand the allocation of greater cognitive and processing resources to speech if intelligibility is to be achieved and maintained. The need to develop intelligible speech may be reduced by social constraints such as limited opportunities to communicate verbally as an equal partner across a range of social contexts. In addition, the motivation to use the ambient speech code as a carrier for language may be reduced in children with Down syndrome by the availability

of social strategies and gestural skills to facilitate non verbal interaction and context based communication.

Constraints on speech intelligibility may contribute to the maintenance of sign and gesture in children with Down syndrome at the stage when these are discarded by typically developing children (Caselli, Vicari, Longobardi, Lami, Pizzoli & Stella, 1998). The prolonged use of early gesture is frequently referred to as a gestural advantage for the child with Down syndrome as it facilitates and sustains interaction and communication. It could also be viewed as contributing to a disassociation between linguistic form and language use at the early stage of formal language development. The consequences of a prolonged period of low speech intelligibility coupled with increasing gestural advantage merits further explorations to identify the levels of abstraction and functionality attained by the promotion of iconic symbolic systems. The role of protolanguage in fostering the development of the referential linguistic system remains unclear and the generalisation of findings from studies of language development in sign language to signed gestures which accompany spoken language may not be apt. Information from linguistic and neurolinguistic studies of bilingualism and protracted language development suggests these may result in different developmental pathways and in different neurocognitive endstates (Bates et al., 1998).

Clinically the disassociation between intelligibility and general language skills indicates a need for a focus on speech or a referential augmentative system at an earlier stage in intervention than is currently the norm. Speech intelligibility has not been a key element in recent approaches to early intervention with children with Down syndrome. Current approaches have focussed on strengths, such as gesture, sign, or written language, but if the speech code is out of synchrony with language at an early stage as suggested by these findings, then this position might need to be reviewed.

7.1.3. Phonological development

Typically developing children begin to apply the rules of the phonological system to their speech before their second birthday and while phonological development continues over the next five years the majority will have developed a stable system in tune with the ambient language by the age of four years. Findings from this study confirmed this pattern of rapid development, albeit at a younger age level than would be expected from the literature, in the typically developing children but indicated delays and restrictions in system development in the participants with Down syndrome across the same language age levels. The typically developing participants demonstrated stable use of the phonological rules of the ambient language at the base language age and showed an even rate of progression towards the target language system. Phonological development in the group with Down syndrome was out of synchrony with general language levels from the early stages of formal language development. Comparison of speech patterns between the groups indicated significant differences between their achievements on all speech measures.

Consonants correct

Percentage of consonants correct scores increased with language levels in both groups. The majority of typically developing children were using all consonants correctly in the samples obtained by language level 2 (43-62 months). The Down syndrome group showed a wider range of scores and significantly lower scores at all language levels. They also showed a decrease in correlations between percentage of consonants correct scores and intelligibility as language levels increased. This may reflect the compensatory measures adopted by the participants in this study to maximize communication while retaining a phonological system at variance with the ambient language.

Phonological processes

The persistence of a high number of phonological processes beyond the age of four is considered as a marker of speech delay or impairment in typically developing children (Dodd, 1995; Hodson, 1998; Shriberg at al., 1994). The typically developing children in this study showed persistence of a limited number of processes at the early language levels but suppression was evident by language level 2. Data from the Down syndrome group indicated a high number of strong active developmental processes across all language levels. The participants in this group showed a median of 7 (mean 7.83) active processes compared to a median of 0 (mean 1.05) in the typically developing group. Process strength was also greater in this group with a median score of 14 (mean 13.88) for phonemes influenced compared to a median of 0 (mean 1.71) in the typically developing group. These findings support and expand on findings of previous studies of speech development in this population (Dodd 1976, Dodd & Leahy 1989; Parsons & Iacono, 1992). The co-occurrence of multiple processes which was specific to the group with Down syndrome in this study was also reported in studies by Parsons & Iacono (1992) and Stoel–Gammon (1981).

Differences were evident in the type of processes present in the groups. All process types occurred with greater frequency in the group with Down syndrome. The typically developing group showed cluster reduction as the remaining active structural process. The Down syndrome group showed a pattern dominated by structural processes across all levels of word and syllable structure as summarised in table 7.1.

Table 7.1 Structural processes by percentage occurrence rate

	%DS Group	%TD Group
Unstressed/Weak syllable deletion	57	0
Reduction to monosyllables	25	0
Reduplication	20	0
Final consonant deletion	71	0
Initial consonant deletion	33	0
Cluster deletion	29	0
Cluster reduction	79	12
Reduction of unstressed syllable	5	0
Replacement of unstressed syllable	3	0
Reordering of segments	4	0

Structural processes are learned early in typically developing infants with studies indicating that these are mastered receptively before the first birthday and expressively by the second (Boersma & Levelt, 1999). The early mastery of the syllable shapes of the ambient language in typical development would suggest that constraints on preverbal development might contribute to their presence in the speech of the participants with Down syndrome in this study. The presence of structural processes has been associated with hearing impairment in typically developing children. The high occurrence rate of these constraints on syllable structure in the Down syndrome group could be associated with the intermittent hearing loss experienced by many of the participants during infancy and childhood. The high number could also reflect representational difficulties due to constraints on categorisation or cross modal representation. Structural processes have a negative impact on intelligibility and on morphosyntactic development by constraining and reducing word form.

Place and manner processes were also more prevalent in the Down syndrome data. Participants from both groups showed fronting of place of articulation as the predominant place process, but this was evident in 43% of the Down syndrome group compared to 11% of the typically developing group. Backing and systemic sound preference was evident only in the data from the group with Down syndrome. Backing and systemic sound preference are rarely reported in typically developing children during the formal stage of language development. The presence of systemic sound preference may indicate the retention of template or whole word learning strategies in these participants. Both groups showed active manner processes such as stopping, gliding of liquids, deaffrication and voicing but these occurred with greater frequency in the Down syndrome group. This group also showed nasalisation, denasalisation and lateralisation.

The data did not show the presence of any processes not previously reported in the literature of typically developing or speech impaired children, thus, supporting the findings of previous studies that the speech patterns found in this population are comparable to those observed in typical development (Dodd 1973; Stoel-Gammon, 1981; Parsons & Iacono, 1992). The group could be described as

delayed on the basis of persisting normal processes (Grunwell, 1997). The additional information obtained from the analyses of process number, strength and type undermines this assumption of a simple delay pattern. The high number of active structural processes and the presence of backing, stopping and gliding processes more closely resemble the patterns identified by Hodson & Paden, (1981) as markers of severe phonological impairment from comparative studies of typically developing children with and without low speech intelligibility.

The number and strength of active co-occurring processes found in the Down syndrome group are not reported in studies of typically developing children who have reached the stage of formal language development. They are considered to be indicative of specific speech impairment and resemble those observed in children frequently classified as having developmental motor speech impairments or dyspraxia (Crary, 1993; Kumin & Adams, 2000; Shriberg, Aram, & Kwiatkowski, 1997).

Phoneme inventories

The groups in this study did not show statistically significant differences in phoneme inventories. Both groups demonstrated the ability to articulate the majority of speech sounds required for the target language but differed on their ability to apply language specific rules to the use of these sounds in words. The typically developing group showed difficulties in the use of middle and late developing sounds at the early language levels which were not evident at the later stages. The inventories of the participants with Down syndrome showed persistent gaps across all phoneme classes at all language levels.

Non target language phonemes were present in the inventories of 16 participants in the Down syndrome group. The majority of additions were fricatives. Individual analysis indicated that these could be due to the influence of place processes with bi-labial fricatives replacing labio-dentals, and palatal, velar or

glottal fricatives/stops replacing dental and palatal fricatives. The addition of non-native language phonemes during the period of formal phonological development suggests a deviation from typical developmental patterns. Difficulties in speech sound production have been identified in other studies of children and adolescents with the syndrome (Parsons & Iacono, 1992; Van Borsel, 1996). They have been described as phonetic or allophonic type errors and as possible signs of developmental apraxia of speech (Kumin & Adams, 2000). Variations in phonetic realisations may reflect differences in perceptual or phonetic constraint rankings, motor planning or execution difficulties in the group with Down syndrome who participated in this study. The constraints on goal directed imitation in infants with Down syndrome noted from the literature could contribute to the setting of broader protophomenic categories at the prelinguistic stage reflected in different rankings of perceptual and/or phonetic constraints in the language system.

Previous studies have concluded that phonological patterns in children and adults with Down syndrome are similar to those seen in typically developing children at younger age levels (Dodd, 1973, Parson & Iacono; 1992; Van Borsel, 1996). The findings of this study support this viewpoint in that comparisons between the groups on consonants correct, process analysis and phonetic inventories revealed similar elements. The mismatch in phoneme inventories and consonants correct between the systems of the participants with Down syndrome and that of the ambient language, along with the number and strength of phonological processes is indicative of specific speech impairment. This would support those who hold that children with the syndrome experience specific difficulties in the development of expressive language form (Chapman, 1995; Chapman et al., 1998) but does not necessarily provide an explanatory framework.

Possible causal factors and mechanisms for the differences observed between the groups in phonological development

The literature review outlined factors which contribute to the development of speech as a carrier of language. The review also identified constraints on inputs

experienced by many infants and children with Down syndrome which may contribute to differences in the cognitive, linguistic and motor processes which foster language.

Input to language as a representational and referential system may be reduced due to sensory, perceptual, cognitive or social constraints. Constraints on language specific input may impose constraints on the developing processes in the first years of life. Atypical attentional states and sensory processes may contribute to deviations in the development of receptive phonological form which may result in delayed development in the recognition of variation in phonetic realizations. This could contribute to delays and differences in the categorisation of the language specific anchor features and boundaries of phonemes, syllables and syllable sequences.

Constraints on cognitive development and information processing may result in restricted knowledge of the world and of the linguistic system to represent it fostering a dependence on inferential decoding. Fuzzy word representations at both semantic and phonological levels may contribute to delays in processing and response formulation.

Constraints on output during the early learning period may restrict production practice hindering the development of oral motor skills in both planning and execution. The persistence of direct imitation may also contribute to additional delays or deviations from typical developmental pathways in those with Down syndrome during this period by delaying the adoption and adaptation of community goals. Delays or deviations from typical patterns of cross modal phonemic representations may result in the setting of broad constraint rankings accommodating allophonic variation which could contribute to later difficulties in motor planning, execution and self monitoring abilities.

The processes which contribute to the development the speech sound system are summarised in table 7.2 with those more vulnerable to disruption due to developmental constraints indicated by bold print.

Table 7.2. Inputs and processes contributing to development of speech

Inputs	Processes	Outputs
To knowledge base • Experience of the world *Input to language content and form* Experience of language • Prosody • Lexicon • Phonology • Morphology • Syntax *Input to language use* • Self identity • Motivational state • Interpersonal interaction • Environmental demands	Sensation Attention **Perception** **Inter-modal organisation** **Categorisation** Memory Representational Semantic **Referential** **Grammatical** Shared attention **Goal directed behaviours** **Imitation** **Motor planning and execution**	Code for functioning in the language community Code for communication

These inputs and processes are not specific to those with Down syndrome but are shared by all language learners but infants with the syndrome may experience greater constraints during the developmental learning period. During this period infants learn to categorise speech inputs into percepts which link auditory and motor experiences. The percepts formed are necessarily fuzzy to enable the learner to accommodate variation in inputs across speakers in features such as prosody, tone and pitch. The ability to accommodate perceptual variation in input fosters goal focussed optionality in output. This may enable and motivate the infant to attempt output to input matching in spite of articulatory constraints and motor mapping of the intermodal space for categorical speech sounds can begin. Cross modal mapping allows the infant to clarify and define phonemic categories using input from self and others to accommodate auditory perception, phonetic

experience and phonemic goals. Learning is motivated by social and linguistic needs to match input to output and proceeds through a gradual reranking of markedness and faithfulness constraints. Figure 7.1 based on models from Boersma (1999) outlines the learning process.

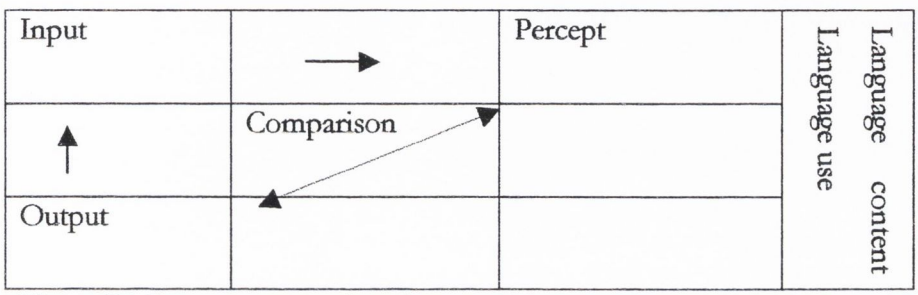


Figure 7.1 Input to output learning process.

The comparison process indicated by the bi-directional arrow is utilised to ensure that the output is faithful to the input and will enforce changes in ranking in the language learner. This process appears to be motivated by developmental needs in infancy but remains active in monitoring output in mature language speakers. The learning role may be reactivated in later years by situations such as second language learning but may not be as accurate in detecting and monitoring featural aspects in the mature speaker. The protracted language learning period experienced by many children with Down syndrome may contribute to a decrease in efficacy of this learning mechanism. The social motivation to match output to input may be compromised if the output matches input sufficiently to serve communication needs. The linguistic motivation may be reduced if the lexicon fails to expand sufficiently to foster referential categorisation.

Protracted development of early language skills and constraints on the development of speech as a carrier for language may clash with an increasing personal need and environmental demands for interpersonal communication. Infants may opt for the continued use of protolanguage as a code for communication if needs can be met with a concrete system. Those who opt to transfer to developing a representational linguistic system may find that sensory, motor and social constraints reinforce early speech patterns and hinder linguistic

change. Over reliance on syllable and word templates may lead to a stabilisation of early speech forms and a reliance on alternative output channels to clarify and maintain communication. If these prove effective, the motivation to refresh phonetic and phonemic categories as vocabulary increases during the period of formal language development may be reduced.

Limitations of the study

The selection and matching of groups for this study limits the value of the findings on both groups. The group with Down syndrome was selected from a clinical population referred because of parental perceptions of communication difficulties and thus may not be representative of developmental patterns in this population. The typically developing children failed to show the variation in phonological patterns expected for two to three year olds. These children were selected from a population considered to be at risk of speech and language impairments which may have been reduced by their attendance at community preschools and by parental involvement in community support schemes and educational programmes.

The study identified disassociations between general language skills and intelligibility, and quantitative and qualitative differences in phonological patterns in the speech of the group with Down syndrome. Similar disassociations have been noted in other components of expressive language form in previous studies (Chapman et al., 1998; Fowler, 1990, 1995). The disassociation of phonological form has been attributed to both the general developmental constraints experienced by infants with Down syndrome and to specific anatomical and functional constraints on speech. The tools used in the study did not allow these differences to be explored in relation to possible constraints associated with the syndrome. Further research is required to determine the contribution of constraints on oral movements, imitation, neuromotor skills and a protracted language learning period to the persistence of speech code at variance with the ambient language form in this population.

Clinical implications

The discrepancy between development of the phonological system and language skills in the participants with Down syndrome indicates a need for attention to the area of phonology or an alternative representational system during the early years. Cognitive and social demands on systems that remain linked to context may result in frustration for the language learner. The learning and motivational styles reported in infants and children with Down syndrome may make them reluctant to change established patterns and dependence on concrete systems of communication may develop. Language, as a representational system, requires the use of abstract units to sustain development.

The disassociation between general language skills and speech intelligibility and phonological development in the children and adults with Down syndrome who participated in this study indicates that the diagnosis of speech impairment should be based on detailed analysis of the phonological system in relation to the speech code and the referential language system as well as to communication skills and needs. The use of language age referencing to diagnose the presence or degree of speech impairment and to determine eligibility for therapy in this population must be queried.

7.1.4. Summary: Study 1 Research questions and possible answers

Does speech intelligibility reflect competency levels in general language skills?

Intelligibility reflected language skills in the typically developing group but failed to do so in the participants with Down syndrome. Low speech intelligibility has been consistently reported as characteristic of the speech of children and adults with Down syndrome (Chapman 1995; Kumin, 1994, Miller, Leddy, Miolo, & Sedey, 1995). The findings suggest that speech development had disassociated from or failed to connect to general language ability and communication skills at the language age of two years in the group who participated in this study.

Do speech intelligibility levels reflect levels of phonological system development?

Intelligibility reflected phonological system development in both groups but there was some evidence that participants in the Down syndrome group achieved higher intelligibility scores than would be expected in view of the restricted phonological contrasts available to them. This may have reflected the use of compensatory strategies including the adoption of a restructured code fostered by life experience. The stabilisation of a restructured code may provide an effective code for communication but may prove restricted as a code for functioning in the language community.

Do the phonological systems of children and young adults with Down syndrome reflect developmental patterns of typically developing children?

The phonological systems of the participants with Down syndrome showed similar elements to those observed in typically developing children but they also showed additional elements traditionally held to be symptomatic of speech impairment or disorder. Analysis of the data indicated that while many elements were shared, the speech systems achieved by those with the syndrome failed to equal the intelligibility levels of the language age matched group. The developmental patterns found in the Down syndrome participant group reflected those reported from studies of typically developing and speech impaired children during early language development but with all elements amplified.

Are there specific characteristics or clinical markers of speech impairment associated with Down syndrome?

This study did not identify any specific clinical markers in the speech of the participants with Down syndrome. The groups were following parallel paths in development of the speech system but those in the Down syndrome group were progressing at a slower rate and with greater variability than their language age matched peers. Their phonological systems showed an 'increased prevalence,.....greater severity, multiplicity and chronicity' (Shapiro 1994: 86) of all elements associated with speech impairment in the wider population.

7.2. Study 2

This study explored associations between development levels in speech and those achieved in vocabulary, morphology and syntax. The findings indicated discrepancies between aspects of the phonological system and the components of language measured.

Table 7.3. Discrepancies in levels attained in the components of language

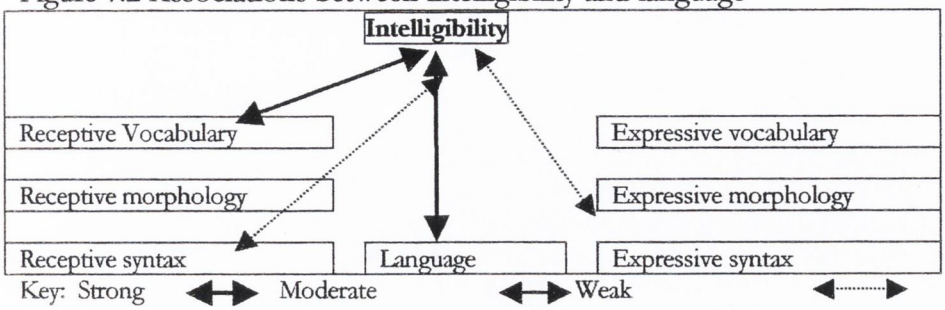
Rated scores (N= 40)	Mean	Median
Language rating	3.05	2
Receptive vocabulary	1.55	1
Receptive morphology	0.93	0
Receptive syntax	0.85	0
Expressive vocabulary	2.83	2
Expressive morphology	1.48	0
Expressive syntax	2	1

The participants in the study showed the impairments of many components of the language system frequently associated with Down syndrome (chapter 3). Their language skills were below the levels expected for their chronological age and asynchronies in development between the components of language were evident (table 7.3 adapted from table 6.4).

7.2.1. Intelligibility

Intelligibility as a composite measure showed significant positive relationships with general language skills and with receptive vocabulary as illustrated in figure 7.2. Relationships between intelligibility and the formal aspects of language were weak or non significant.

Figure 7.2 Associations between intelligibility and language



These findings indicate that intelligibility has stronger links with language content and use than with language form. Speech intelligibility levels in interpersonal communication are motivated by communication needs, context and strategic competence. Speakers use many strategies to ensure that they achieve their communication goals. Studies of language development indicate that caregivers provide many of these strategies in interactions with infants as they support them in early language development. Studies of language change in multilingual contexts also indicate that speakers cooperate actively to achieve effective communication. In both instances, communication efficacy may be increased by sacrificing language form.

In situations where language form is not shared regression to the unmarked may occur in the organisational rules applied to word and sentence structures. Both speaker and listener tolerate variability in phoneme inventory and use in these contexts. The acceptance of variability during early language development facilitates the development of communication intent and allows the learner time to master the form of the language. The constraints on learning in infants and children with Down syndrome along with the social constraints imposed by dense social networks may contribute to habituation of a supportive communication pattern. This pattern may also be fostered by programmes which reduce input, restrict vocabulary and focus on language use for interactional purposes. Reduced exposure to language form across contexts may not provide the learner with sufficient information to abstract the organisational rules of language form.

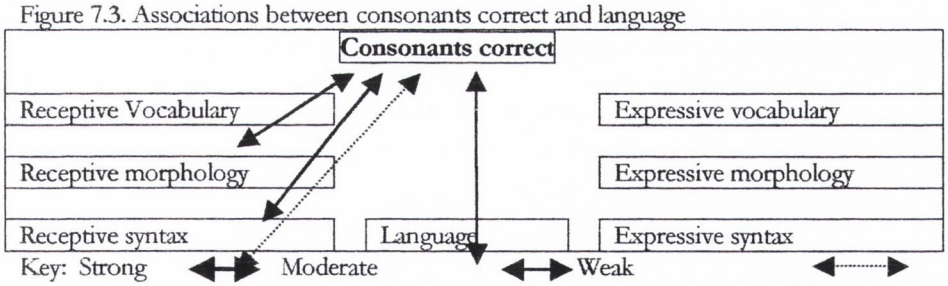
7.2.2. Phonology

Patterns of association between rated scores based on percentage of consonants correct, process number and process strength and rated scores for the components of language were identified.

Consonants correct ratings

Consonants correct ratings showed significant correlations with receptive language measures but none with expressive. Consonants correct rating measure differences between learner and mature phonological systems. These were estimated in this study by a picture naming task. While this task allowed all phonemes to be sampled, it placed minimal demands on expressive language skills. This may have contributed to the lack of relationships between consonants correct and the expressive language components found in this study. Further research with broad based measures of consonants correct across linguistic and social contexts would be required to explore patterns of association. The lack of relationship may also be due to the inhibitory effects of phonological impairment on the language output of participants in a clinical study.

Figure 7.3. Associations between consonants correct and language



The significant association between consonants correct and receptive vocabulary would support theories which stress the importance of lexical development in motivating the development of language form. The lack of relationships with expressive language measures may reflect the disassociation between receptive and expressive skills found in typically developing children (Bates et al., 1995) or could also support the view that expressive language disassociates from receptive

in the early developmental period in infants and children with Down syndrome (Chapman, Seung, Schwartz & Kay Raining Bird, 1991; Miller 1995).

Phonological process analyses

Phonological processes analyses were used in this study to identify and rate the number and strength of natural processes observed in speech behaviours. Studies of typically developing children indicate that these processes are suppressed as language specific knowledge increases and phonological forms are mastered. Positive associations were found with all aspects of language (figures 7.4 and 7.5).

Figure 7.4. Associations between process number rating and language

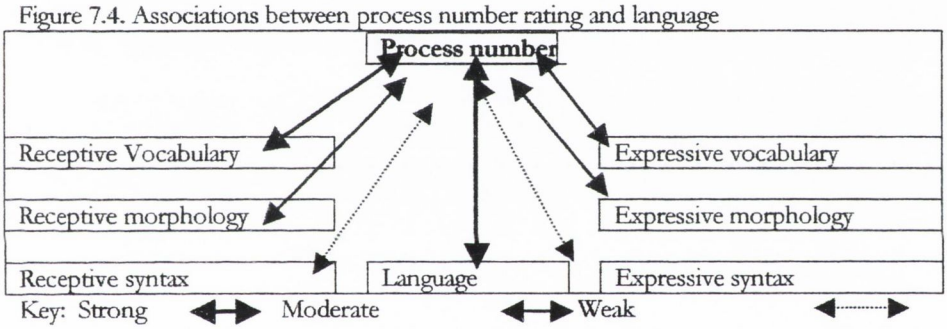
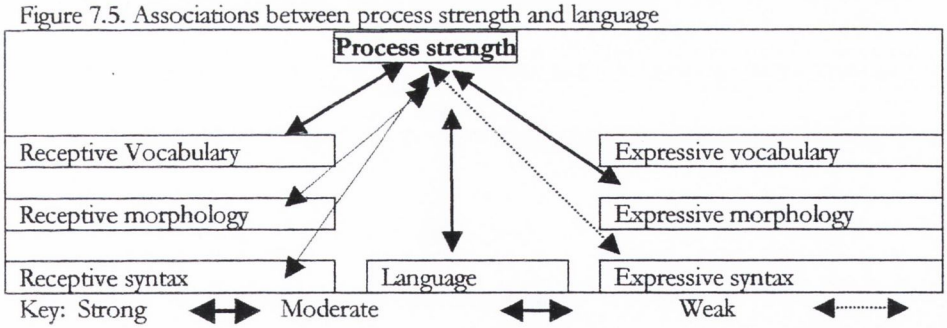


Figure 7.5. Associations between process strength and language

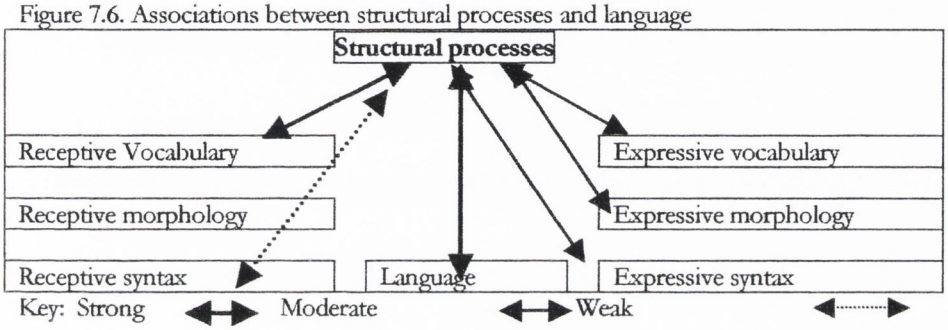


Process type

Structural processes reflect knowledge of the syllable and word formation rules of the ambient language and associations with both the lexicon and with the formal language system would be predicted from the literature. This study found significant negative correlations between structural processes and all components

of language with the exception of receptive morphology (figure 7.6). Developmental studies suggest that structural form is learned first receptively in infancy and that structural processes are suppressed first in babble and early speech (Hayes, 1999 b; Pater 1997). Delays in development in the development of knowledge of syllable and word form may impact negatively on later vocabulary learning and categorisation skills.

Figure 7.6. Associations between structural processes and language



The lack of a statistically significant relationship with receptive morphology may be due to the of lack accuracy of the measures used. It could also indicate specific difficulties in receptive morphology in children and adults with Down syndrome. Specific difficulties in receptive morphology have been reported in studies of adolescents and adults with the syndrome (Chapman, 1997; Rondal & Comblain, 1996).

The strong negative association with receptive vocabulary could be indicative of restricted or flexible word forms reported in the speech of typically developing children before the stage of formal language acquisition. Restricted vocabulary and flexible word forms are also found in pidgin codes where they may stabilise into fixed forms as creoles develop. This development appears to be triggered by increases in the content and functions served by the pidgin or creole.

The relationship between the lexicon and the phonological system in early language development is unclear but most would agree that the initial restricted vocabulary of protolanguage is associated with the development of fixed

phonological forms. The rapid gains in vocabulary after the early 'vocabulary spurt' is associated with the development of the organisational rules of the phonological system in typically developing children. The stabilisation of proto-phonological forms may account for the prevalence of structural processes in the speech of the participants in this study. The persistence of early sound patterns as content and use demands increase will impose further constraints on all aspects of the developing speech system.

Place and manner processes would not be expected to show associations with the formal language system language due to their articulatory nature. Associations with the lexicon would be expected if word form encodes phonological knowledge. This was not identified in the results. The lack of association between manner and place processes with receptive vocabulary could also be indicative of fuzzy lemmas or of flexible undifferentiated phonological representations at word level

System ratings

System ratings as used in this study measured markedness based on constraint ranking. All participants exhibited the dominance of markedness over faithfulness thus supporting predictions from optimality theory (Smolensky, 1996b). The majority showed constraints on syllable structure (table 7.4) thus reflecting the findings of process analysis.

Table 7.4: Constraint rankings: Markedness dominated faith

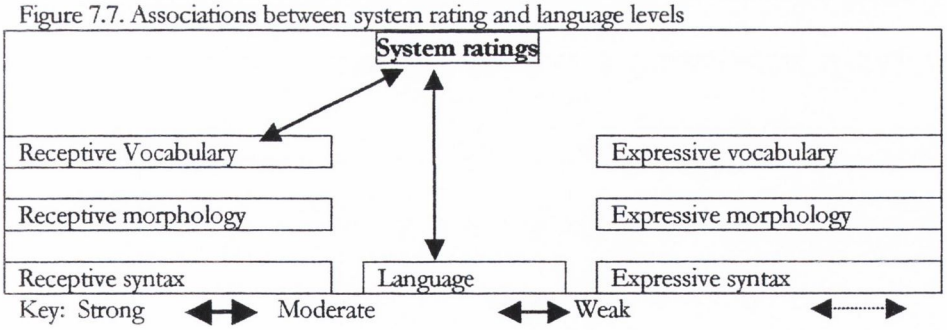
Constraint	Ranking	% of participants
* Coda plosive	* Coda plosive >> Max	83%
* Coda fricative	* Coda fricative >> Max	83%
*Coda nasal /liquid	* Coda nasal /liquid >> Max	53%
* Complex S	* Complex S >> Max	98%
* Complex O	* Complex O >> Max	90%

The high occurrence of open syllables identified is similar to patterns seen in early acquisition (Ingram 1989). Outputs that include a final consonant violate the markedness constraint NO CODA (McCarthy & Prince, 1995). This constraint is dominated by the faithfulness constraint MAX (no deletion) in the mature English grammar but the reverse ranking was found in this study. The lower number showing a constraint against final nasal and liquids could indicate differential ranking of *coda based on segmental markedness in these participants.

Consonant clusters are considered to be marked relative to singletons and occur less frequently in languages (Blevins, 1995) and appear later in acquisition. Constraints on complex onsets have been found to co occur with coda constraints in language development and in pidgin and creole languages. The rankings found in this study reflect this pattern. Differences in the incidence of the rankings of constraints against / s/ clusters (* Complex S) and other consonant clusters (* Complex O) also show the influence of segmental markedness.

These constraints may be responsible for the significant correlation with receptive vocabulary outlined in figure 7.7.

Figure 7.7. Associations between system rating and language levels



System ratings showed moderate negative correlations with language and receptive vocabulary. There were no statistically significant relationships with other measures.

Constraints against place or manner of production related to segmental markedness were also identified in this study. These are summarised in table 7.5.

Table 7.5. Constraint rankings

* Dorsal	* Dorsal >> IDENT Feat /place	13%
*Coronal	*Coronal >> IDENT Feat / place	23%
* Fricative	* Fricative >> IDENT Feat / manner	25%
* Liquid	* Liquid >> IDENT Feat / manner	73%
*Artic precision	*Artic precision >> IDENT Feat place / manner	10%

* DORSAL Dorsal consonants are perceived as more marked than coronals and a segmental markedness constraint against dorsals has been reported in developmental literature (Smolensky, 1996b) and is frequently identified in children with speech impairment.

*CORONAL was included in the rating scale for this study to account for the process of backing of coronal consonants frequently reported in children with impaired / restricted phonological systems (Cheung & Abberton, 2000). This constraint conflicts with markedness theory but was included as a possible marker of speech impairment. The occurrence rate of 23% could indicate potential as a clinical marker but more knowledge is required on the occurrence of this constraint in the phonologies of typically developing children before any definitive conclusions can be reached

* FRICATIVE is frequently reported as occurring in child phonology with the markedness constraint against fricatives resulting in a their substitution by the more unmarked plosives. This ranking was evident in 25% of the participant systems in this study

*LIQUIDS was ranked above identify feature/place in 73 % of the samples. Liquid consonants are considered as marked by their low frequency of occurrence cross - linguistically and late acquisition in developing phonologies (Barlow & Gierut, 1999).

Reduced articulatory precision was seen in 10% of samples. These included inconsistent errors or substitutions which appeared to have a motoric basis such as lateral release on fricatives and affricates and deaffrication.

The use of a rating scale based on constraint ranking indicated that constraints against markedness dominated over faithfulness to the ambient language in the phonological systems participants.

Limitations of the study

The study used speech measures based on those in current clinical use. The findings indicate that they sampled disparate elements of the phonological system, which vary in their relationship to the language system. This may be attributable to specific characteristics of the population studied but shortcomings in models, tools and sampling procedures oppose this conclusion.

Measures of the language components did not capture the adaptive strategies used by participants in this study to maintain communication efficacy when speech is compromised and their influence on both intelligibility and development of the phonological system cannot therefore be calculated. The relationships found between the selected components of language were tentative and dependent on the aspects of the phonological system measured. Broad associations with language, receptive vocabulary and syntax were identified but no specific patterns were evident.

Clinical implications

Low speech intelligibility was associated with systematic variation in the phonological system in the groups studied. The constraints against markedness in the phonological component of form also appeared to be reflected in morphology and syntax. This finding suggests that low speech intelligibility could be associated with the adoption of a systematic unmarked code as functional for communication. This code resembles that identified in developing languages and in situations of language change where function dominates content and form. The measures used in this study did not allow these to be explored in greater detail but if the speech code reflects this pattern, changes in current assessment and therapy would be indicated. Current measures facilitate comparison and quantification of relationships between learner and mature speech systems but may fail to identify

associations across language form. The associations if verified could contribute to changes in intervention which could focus on adapting a system rather than tackling a symptom.

7.2.3. Summary Study 2: Research questions and possible answers

Is speech intelligibility level associated with levels of development in general language, or in receptive or expressive, vocabulary, morphology or syntax?

Intelligibility levels were associated primarily with language content and use thus supporting the label of 'good communicator; poor speaker'. The adaptive strategies used by the participants to increase intelligibility were not measured in this study but the findings suggest that many compensated for difficulties in speech by adopting a restructured code where use and content dominated form to serve communication needs.

Do measures of the phonological system show patterns of association with levels of development in receptive or expressive vocabulary, morphology or syntax?

The measures of the phonological system used in this study showed relationships with many components of the language system but no specific patterns of associations were identified. Consonants correct ratings showed significant correlations with receptive language measures but relationships with expressive language were weak The number of processes present showed significant associations with all language components while process strength correlated with all language components except expressive syntax. System rating showed negative associations with language and receptive vocabulary and non significant relationships with other components of language. The lack of association with expressive language measures may have been due to the inhibitory effects of low speech intelligibility.

7.3. Study 3

Study 3 investigated changes in aspects of speech and the components of language over a thirty month period with data obtained at three time points for one group of participants and at two points for the other (outlined in table 7.6). The findings indicated that significant changes occurred in speech intelligibility levels, in expressive phonologies and in language measures.

Table 7.6. Study 3. Time frame and data collection points

	Time 1		Time 2		Time 3
Group A (n=20)	Pre test 1	Indirect intervention	Pre test 2	Direct intervention Phonology therapy	Post test
Group B (n=20)	Pre test	Direct intervention Phonology therapy	Post test		

7.3.1. Changes in intelligibility and phonology

There was no change evident in intelligibility ratings of Group A following the initial period of indirect intervention but significant increases were evident between times 2 and 3. The lack of change in the pre-intervention period followed by significant change in the post therapy measures suggest that the development of intelligibility was facilitated by the period of direct intervention. Group B also showed significant gain in intelligibility in pre and post therapy ratings. The therapy programmes were phonologically based and changes in intelligibility were therefore expected to be associated with changes in the phonological systems.

The results indicated significant change in consonants correct, process number and strength rating, process type and system rating.

Consonants correct

Consonants correct ratings showed significant increases in both groups at all time points. Group A showed a significant increase following the indirect intervention period. This increase in consonants correct did not appear to impact on everyday

intelligibility levels or on the phonological systems of the participants as no significant increases were evident in intelligibility or in process measures. The increase appeared to represent a change in surface patterns, which could be interpreted as indicative of developmental change in progress or alternatively could reflect an increase in word templates available in the expressive lexicon. Both could be attributed to maturation or to changes in the language environment.

Changes in the language environment, with an increased focus on speech by families, would be expected following the information sharing that occurred at the initial assessment session and attendance at parent workshops. The assessment sessions were observed by parents/ siblings allowing them to share in the identification of patterns of strengths and weaknesses in client's speech and language. The purpose and findings of each measure was discussed following the session which would have added to knowledge of the components of verbal communication. Many family members attended workshops which provided information on language development and on ways to facilitate speech and language development. These were intended for the parents of unsuccessful applicants but as no restrictions were placed on attendance many of the parents allocated places on the therapy programmes attended. The workshops had been designed to allow carers to identify strengths and weaknesses in speech and language using rating scales, and provided specific suggestions on maximising development in these areas. They are likely to have brought about changes in the attitudes and behaviours of the families of the participants in the deferred therapy group. Similar parental programmes by Dodd (1995) indicated that changes in speech sound systems could result from indirect intervention. The acceptance of the child /adult for the project may have changed family perception of their potential as a speaker and encouraged a focus on speech in the home. All of the above could have initiated developmental change or fostered increased attention to speech production which could result in limited changes in speech systems.

The increase in consonants correct could reflect changes limited to formal speech patterns in the group as measured by the picture naming task. Picture naming in an assessment context may elicit a code or lect closer to the standard form due to social influences. Variation in language form due to social context and participant status has been reported in studies of language and dialectal change (McMahon, 1996). The increase in consonants correct found in this study may indicate that the participants had knowledge of the language appropriate phonological forms and the ability to apply this knowledge to their speech but were not transferring these across the wider range of communication contexts. The reduced ability to transfer knowledge and skills has been frequently linked to the cognitive constraints imposed by general learning difficulties. This has resulted in the difficulties in speech experienced by children and adults with Down syndrome being explained by their reduced ability to cope with the higher processing demands of verbal communication. The changes evident in intelligibility and consonants correct post therapy could undermine this assumption.

These changes occurred over a short period through focus on the linguistic system. The changes in consonants correct following therapy were similar to the gains expected in typical developing phonological systems during the period of accelerated development in language form at the three to four year level. The systematic nature of these changes was evident in process analyses and in the gradual promotion of faithfulness constraints in system ratings.

Process Measures

The participants showed use of multiple structural and systemic phonological processes at time 1. These resulted in word and syllable structures characteristic of speech during the pre formal stage in typically developing children where the focus is on semantic rather than phonemic form. There were no significant changes in the number, strength or type of processes in Group A between time 1 and 2.

Significant changes occurred in process number and strength ratings in both groups post therapy indicating process limitation and suppression as predicted by theories of natural phonology. Process number proved to be an unstable measure of systematic change as it failed to allow for increases in place and manner processes as structural processes were suppressed.

Analysis by process type indicated significant decreases in structural processes thus indicating that the changes observed followed patterns that would be predicted from the developmental literature and phonological theories.

An increased number of place processes were evident in Group A at time 3. This result was unexpected but explained by an increase in place processes as systemic sound preference and deletion processes were suppressed.

Clinically significant changes in manner processes were evident in limitation of developmental systemic processes. These were not captured in numerical scores at time 3 when residual errors indicated that processes such as gliding and deaffrication were still active. In addition, substitution of one developmental process for another was seen in some participants with stopping replaced by lateralisation.

Qualitative evaluation of the changes in process number, strength and type seen in the groups following therapy followed the predicted patterns of developmental change proposed by phonological theories. The rate and type of change that occurred cannot be evaluated in relation to typical development due to lack of knowledge on process suppression in early language.

System rating

Comparison of system ratings from both groups indicated significant changes at all time points. Changes in rankings showed the predicted move from unmarked to language specific phonologies as summarised in table 7.7.

Table 7.7. Summary of changes in system rating across three time points

Constraint	Ranking	Time points and % of participants				
		A 1	A 2	A3	B1	B2
*Coda plosive	* Coda plosive >> Max	85%	85%	15%	88%	15%
*Coda fricative	* Coda fricative >> Max	85%	60%	0	88%	0
*Coda O	* Coda O >> Max	60%	35%	10%	55%	0
* Complex S	* Complex S >> Max	95%	90%	25%	95%	30%
* Complex O	* Complex O >> Max	95%	75%	20%	95%	20%
* Dorsal	* Dorsal >> IDENT Feat /place	15%	15%	0	10%	5%
*Coronal	*Coronal >> IDENT Feat / place	30%	20%	0	5%	0
* Fricative	* Fricative >> IDENT Feat / manner	25%	15%	0	30%	0
* Liquid	* Liquid >> IDENT Feat / manner	70%	60%	10%	80%	15%
*Artic prec.	*Artic precision >> IDENT Feat place / manner	5%	5%	85%	15%	65%

Similar patterns of change were seen in the rerankings of both groups. Changes in Group A between times 1 and 2 suggested that participants were moving towards typical developmental pathways during this period with the ban on coronal constraints reduced and the constraint on codas restricted to more marked segments. The initial changes in Group A during the period of indirect intervention were amplified in both groups post intervention.

Rapid promotion of syllable and word faithfulness constraints above markedness constraints occurred in both groups. The influence of segmental markedness was also evident in rerankings of coda and complex onset constraints. All promotions indicated a move towards the target language rankings of the selected constraints.

The speech patterns post intervention showed errors which appeared to have an articulatory basis. These included lateral release of friction on coronals and inconsistent gliding of liquids in clusters. These patterns were captured to some extent by the inclusion of constraints against coronals and articulatory precision included in the rating. These had been included to capture tendencies identified clinically and from the literature review in impaired phonological systems in children and adults with Down syndrome.

No coronal

A constraint against coronals was included in the rating scale to account for the process of backing of tongue blade sounds frequently reported in children with impaired / restricted phonological systems (Cheung & Abberton, 2000). Backing and glottal replacement have also been identified in studies of phonological impairment in children and adolescents with Down syndrome (Dodd & Leahy 1989; Parsons & Iacono, 1992; Van Borsel, 1996) and was seen in the findings of the first study in this series.

This constraint conflicts with markedness theory but the reported occurrence in the literature and the findings of this study suggests that it may serve as a marker of speech impairment. The changes over time seen in those with *coronal are summarised in tables 7.8 and 7.9.

Table 7.8 Group B:Changes in systems showing *coronal at time 1

	Time 1	Reranked	Time 2
18	*Coda plosive *Coda fricative *Coda other *Coronal fricative *Complex s *Complex o *Liquid	*Coda plosive *Coda fricative *Coda other *Coronal fricative *Complex s *Complex o *Liquid	Articulation Inconsistent voicing/devoicing fricatives Deaffrication /tʃ/ >/tj/

Table 7.9. Group A: Changes in systems showing *coronal at time 1

Part-icipant	Time 1	Re ranked	Time 2	Reranked	Time 3
2	*Coda plosive *Coda fricative *Coda other *Coronal *Complex s *Complex o *Liquid	*Coda other	*Coda plos. *Coda fric. *Coda other *Coronal fricative *Complex s *Liquid	*Coda plos. *Coda fric. *Coronal fricative *Complex s *Liquid	Articulation Deaffrication within words /ɹ/<->/l/ inconsistent in clusters
4	*Coda plosive *Coda fricative *Coda other *Coronal Fricative *Complex s *Complex o	None	*Coda plos. *Coda fric. *Codaother *Coronal Fricative *Complex s *Complex o	*Coda plos. *Coda fric. *Coronal Fricative *Complex o	*Coda other *Complex s Articulation Lateral release all fricatives syllable final
9	*Coda plosive *Coda fricative *Coronal *Complex s *Complex o *Liquid	*Cor.	*Coda plos. *Coda fric. *Complex s *Complex o *Liquid	*Coda plos. *Coda fric.	*Complex s *Complex o *Liquid Articulation Inconsistent Inconsistent
12	*Coda plosive *Coda other *Coronal *Complex s *Complex o	*Cor.	*Coda plosive *Coda other *Complex s *Complex o	*Coda plosive *Complex o	*Coda other *Complex s Lateral friction /s z ʃ/
13	*Coda fricative *Coda plosive *Coda other *Coronal *Complex s *Complex o	None	*Coda fricative *Coda plosive *Coda other *Coronal *Complex s *Complex o	*Coda fricative *Coda other *Coronal *Complex s *Complex o	*Coda plosive Articulation Residual /ɹ/ > /w / clusters Time 1 Cor > Glottal Time 2 Cor > dorsal / Glottal Time 3 Lateral release coronal fricatives
16	*Coda fricative *Coda other *Coronal *Complex s *Complex o *Liquid	*Coda fric. *Cor.	*Coda other *Complex s *Complex o *Liquid		Articulation Lateral release in sl sm sn sw clusters and /s z / within words

All participants who presented with a constraint against coronals at time 1 showed a greater difficulty with complex articulatory patterns post therapy as indicated by variations in segment realisation such as lateralisation and in inconsistencies in overall production patterns. These patterns are suggestive of a phonetic or motor speech involvement.

Articulatory precision

This constraint was used in order to account for phonetic errors at the segment level such as lateral release and errors which could be due to phonetic environments. Inconsistencies were also included in this ranking. The increase in articulatory errors could reflect residual errors in the majority of participants (tables 6.20 and 6.21) and should not therefore be seen as indicative of severity of impairment. Residual error patterns are frequently reported in immediate post therapy measures and are accounted for by the gradual patterns shown by sound change in languages both developmentally and diachronically (McMahon, 1996: Smolensky & Levelt, 1999).

The constraints against articulatory precision used in the study proved too broad to have explanatory power. It is suggested that they could reflect the acceptance of a wider band of allophonic variation or a 'fuzzy' phoneme which could reflect constraints on goal directed imitation during early development. These could be associated with perceptual or articulatory constraints proposed by Boersma (1999) as phonetic factors contributing to phonological form.

The overall pattern of change observed in system ratings reflected those reported in the developmental literature and predicted from connectionist modelling based on optimality theory. The rerankings observed reflected promotion of faithfulness over markedness. They mirrored the rapid developmental change in phonological form seen in early language development in typically developing children.

Possible causal factors for the changes in phonological system

The findings of Study 3 indicated accelerated orderly phonological change in the children and adults with Down syndrome who participated in the phonological therapy programmes. Significant changes in intelligibility levels and in consonants correct, process measures and system ratings indicated that the participants by the end of the study were using the phonological rules of the ambient language in speech. These changes appear to be due to both the structured nature of the

programmes which were based on individual phonological system profiles and used phonological processes and multiple exemplars (Gierut, 1989) and to the time and attention allocated to speech by carers. Three therapy approaches were used and while all promoted systematic change, there was insufficient data to allow efficacy to be compared (appendix 4.1). Patterns of change across the groups would suggest that programmes which focused on meaningful contrast and repair strategies resulted in more rapid gains in intelligibility. This could support the use of language use or function to modify form. However, analysis of therapy sessions indicted that these programmes indirectly targeted the lexicon in content. Studies of language change would indicate that increases in the lexicon motivates changes in form. Further explorations are needed to identify specific factors which cause systematic change in phonology as a component of language form.

Limitations of study and implications for research

The developmental change patterns and possible markers of speech impairment identified in this study may not be typical of children and adults with Down syndrome because of selection procedures, small numbers and measures used. The use of a rating scale to measure speech intelligibility provides a broad indication the accuracy of speech production which may over or underestimate the intelligibility of speech in different contexts. The measures of the phonological system and sampling procedures used in the study while allowing broad based comparisons of surface patterns did not allow detailed in an depth analysis of speech patterns across a range of contexts.

Process analysis while providing useful qualitative information on patterns of process limitation and suppression proved unsuitable as a quantitative measure. Further studies using more comprehensive sampling, measuring and analytic procedures are needed to verify the patterns suggested by these results. These may emerge from current work in functional phonology and optimality theory

which are allowing increasing formalisation of articulatory and gestural constraints.

The finding of residual errors in a large number of participants leaves the question of the permanence of changes in the phonological system unanswered. Sound change in languages and phonological change in development show similar 's' shaped learning curves with slow development initially followed by rapid change and a final period of decelerated change. Final measures in this study were taken within a short time of therapy completion when developmental change may have been incomplete. Follow up measures would have allowed more detailed conclusions on learning patterns and phonological change in children and adults with Down syndrome.

Clinical implications

The findings of this study suggest the need for changes in clinical approaches to speech impairment in children and adults with Down syndrome. The significant changes in speech intelligibility and the patterns of change seen in the phonological systems of the participants suggest better outcomes than are usually reported in studies with this population (Dodd & Iacano, 1989; Buckley, 2000; Rondal, 1996). This could be attributed to the tendency of early programmes to focus on phonetic form and phonemes in isolation in contrast to the system based approach used in this study. Phonologically based therapy has been used with success with typically developing children with speech impairment for the last decade (Gierut, 1998).

The findings of this study combined with those of Studies 1 and 2 do not identify specific clinical profiles in the speech of children and adults with Down syndrome which would support the use of motor skills based approaches alone to this population when they present clinically with impaired speech. The participants in the studies presented with the ability to produce a similar range of phonemes and contrasts as typically developing children. They showed similar patterns in the application of the organisational rules of the phonological system as are reported

in the speech of children at the early language learning stage and in the speech of children with phonological impairment.

In addition, the findings of studies 2 and 3 indicate that those with Down syndrome share the patterns in motor speech planning and execution noted in the general population of children who present clinically with speech impairment (Grunwell, 1997). This group may require attention to phonetic detail and motor production in therapy programmes. Further studies are required to determine the optimal order, focus and timing of intervention with those who present with combined phonological and phonetic difficulties. Future studies will require the development of more accurate measurement of the influence of phonetic and perceptual factors on the developing phonological system.

7.3.3 Changes in phonology and language

The participants in these studies presented with many of the developmental differences in the components of the spoken language frequently reported in the speech of children and adults with Down syndrome (chapter three). They presented with lower achievements in general language skills, vocabulary, morphology and syntax than would be expected from their achievements in social, cognitive and physical skills at the start of the study. These discrepancies were not addressed in the therapy programmes but changes were predicted in components of language from the developmental literature.

Gains in intelligibility are associated with rapid lexical expansion and systematic changes in phonology, morphology and syntax in typically developing children. These co-occur developmentally with increasing motivation to communicate and increasing demands for verbal communication by wider social network experienced by the three to four year old child. The participants in the study showed rapid gains in intelligibility following a period of phonological therapy. These were accompanied by changes in all language measures. These are summarised in table 7.10 (full results in tables 6.22 to 6.24).

Table 7.10. Summary of changes in language ratings

Median scores	Group A (n=20)					Group B		
	Time 1	Time 2		Time 3	sig	Time 1	Time 2	
Language rating	2	2	*	4	***	4	6	***
Receptive vocabulary	0	2	*	2	***	2	3	*
Expressive vocabulary	1	3	*	4.5	***	3.5	5	*
Receptive morphology	0	1	**	2	ns	1	2.5	***
Expressive morphology	0	2	*	4	**	1	5	***
Receptive syntax	0	1	*	1	ns	1	2	**
Expressive syntax	0	3	**	3.5	***	3	5.5	***

The rated scores were based on language age equivalencies extrapolated from test manuals and should therefore be viewed and interpreted with caution. The approximate ages in months are indicated in table 7.11.

Table 7.11. Rated scores and approximate language age equivalencies

Rating	1	2	3	4	5	6	7	8	9	10
AAE	24-30	31-36	37-42	43-48	49-54	55-62	63-68	69-74	75-78	79-84

The changes evident in general language skills, vocabulary, morphology and syntax and their possible relationships to changes in speech intelligibility and the phonological system are discussed in the following section.

General language skills

The groups showed differences in language ratings at all time points which may have contributed to changes in learning patterns. Group A at times 1 and 2 showed a median rating of 2 with an approximate age equivalency of 31-36 months. Group B ratings showed a median of 4 with an approximate age equivalency of 43-48 months. Both groups showed significant gains equivalent to an approximate 12 month gain on test results. The gain in group A between time 1 and 2 while significant, was approximately a third of that achieved by both groups following therapy. When evaluated using age related measures this gain

was equivalent to 3-4 months a gain which would be in line with overall developmental progression in children with learning difficulties while the pre and post therapy gain was approximately 12 month.

Correlations between language levels and speech measures indicated a stronger positive relationship with consonants correct at post tests in both groups. Consonants correct measures reflect discrepancies between the phonological system of a learner and the phoneme contrasts needed for the ambient language code. The increasing strength of the relationship would suggest that the phonological systems of the participants in these studies were increasingly in line with the target language. The increasing strength of the relationship between system ratings and language would also support an increasing match between the learner and target systems with the increasing stronger negative relationship indicating promotion of faithfulness over markedness constraints. Process measures while showing statistically significant differences over time proved to be clinically unstable and no inferences can be drawn from the results.

Vocabulary

Both groups started from a different base in receptive vocabulary with group A at level 0 (below 24 months) at time 1 but achieving the level of group B by time 2. Both groups started therapy at similar vocabulary levels which approximated those expected of typically developing children at 31-36 months and both showed similar gains. Relationships between receptive vocabulary and speech measures showed no significant changes over time.

The groups varied in levels attained in expressive vocabulary at all time points. Group A showed a rating of 1 (24-30 months) at time 1 increasing to 3 (37-42) at time 2 and 4.5 (43-48 months) post therapy. Group B showed a rating of 3.5 (37 - 42 months) pre therapy increasing to 5 (49 -54 months) post therapy. These results may reflect the delayed start of the vocabulary spurt in children with the

Down syndrome (Mervis 1990; Miller 1995) and changes may be unrelated to the therapy programmes but it is also possible that the stabilisation of phonological form facilitated the development of vocabulary.

Relationships between expressive vocabulary and all speech measures increased in strength by time 3 in group A. Group B showed an increase in relationship between expressive vocabulary and consonants correct, process strength and system ratings. These gain may have reflected the increased ability and confidence in the participants in their ability to communicate intelligibly.

The discrepancy between receptive and expressive vocabulary ratings found in this study may have reflected different degrees of abstraction in the vocabulary measures selected. The expressive rating was derived from responses to pictures and questions based on everyday experiences. The British Picture Vocabulary Scale was used to estimate receptive vocabulary. The test items on the scales show a rapid shift towards both specific lexical items and categorical knowledge between the three and four year levels to sample the broader knowledge base of typically developing children at this age level. These may not be appropriate to sample the vocabularies of children and young adults with Down syndrome in view of the social, cognitive and educational constraints on learning often experienced by this population.

Morphology

Differences were evident in both groups in receptive and expressive morphology. Group A started from a base of 0 (below 24 months) at time 1 and showed gains in both receptive and expressive aspects by time 2 with ratings indicating levels of 24-30 months in receptive morphology and 31-36 months in expressive. Further development by time 3 indicated receptive ratings of 2 (31-36) and expressive ratings of 4 (43-48 months). The accelerated development in expressive morphology following therapy was also seen in group B who showed ratings of 1

for both receptive and expressive morphology at time 1 and 2.5 for receptive and 5 for expressive at time 2. The expressive gain shown by both groups may be due to nature of the measures used but could also reflect increasing attention to word form with development of the phonological system. The relationships between receptive morphology and speech measures varied between the groups and over time with no evident pattern. Relationships between expressive morphology and all speech measures showed an increase in strength over time which would be expected as the mastery of phonological form should facilitate the realisation of morphological rules.

Syntax

The patterns identified in morphology were mirrored in syntax. Group A started from a base of 0 at time 1 and showed gains in both receptive and expressive aspects by time 2 with ratings indicating levels of 24-30 months in receptive and 37-42 months. No gains were evident in receptive syntax at post test and slight gains only occurred in expressive aspects. Group B ratings showed a significant gain from a median score of 3 (31-36) at time 1 to a median of 5.5 at post test in expressive syntax. Relationships between receptive and expressive syntax and speech measures increased over time in both groups.

Possible causal factors for changes in phonology and language

The participants showed significant changes in language and phonology over the period of the study. These gains could be attributed to many factors outside the control of the programmes.

The gains in general language skills and in vocabulary, morphology and syntax indicated by the findings in group A over the pre therapy may be attributed to

- Maturation

- Parental focus on speech and language in everyday communication contexts

The gains following a period of direct intervention focused on phonology may be attributable to the above factors and others including

- Parental focus on speech contributing to
  - Increased expectations of their child as a speaker
  - Increased use of clarification requests and phonetically contingent responses
  - Increased demands on the child to communicate verbally
- Parental and family focus on speech and language – in everyday communication contexts as well as an increased focus on speech
- Increased one to one interaction between parent and child – in travel to and from therapy, during therapy sessions and in the implementation of home programmes
- Modeling and reinforcement provided during daily therapy activities
- Increasing opportunities and reinforcement for child to interact verbally both directly in therapy and indirectly through parental involvement
- Increasing motivation to use language as intelligibility increased.
- A broader range of social contacts through attendance at therapy sessions - therapists, students and others encountered in the waiting area.

The factors above indicate some of the many influences which could initiate and foster change in the development of verbal communication.

It is also possible to speculate that general language development in these groups was accelerated by the development of the phonological systems by participation in structured therapy programmes. This speculation would be supported by the significant gains in morphology and syntax as components of language form. The earlier stabilisation of a restricted code favouring unmarked forms could have blocked development in language form. The mastery of phonemes at a referential level the development of abstraction in other components of language.

The therapy programmes focussed solely on the phonological systems. They targeted potential causal factors associated with phonological impairment.

Auditory bombardment programmes adapted from the work of Hodson and Paden (Hodson, & Paden, 1983; 1991; Hodson, 1992) were used to target listening skills and to foster the development of cross modal imitation and representation of speech. Metaphonological programmes based on Metaphon (Howell & Dean, 1994) focussed on developing phonological representation at a cognitive level. A motor skills programme was used to develop neuromotor planning and execution skills. All programmes were based on individual phonological analysis and used phonological processes and multiple exemplars in target selection and therapy content. Each participant attended for 20 therapy sessions over a 6 - 8 month period.

These programmes did not focus directly on the lexicon or on other components of language form but development in these areas may have been fostered by many factors in the learning environment. The development of the lexicon may have resulted from the vocabulary used in therapy sessions and the reinforcement provided for appropriate forms. Studies have indicated positive phonological change from a stabilisation of lexical form Dodd (1995). Developments in general language skills, syntax and morphology may have resulted from contingent modelling, expansion and reinforcement provided routinely in clinical interactions.

Limitations of the study and implications for research

The small number of participants in the groups and the many factors which influence the development of language content form and use for verbal communication limit the value of these results. The study identifies accelerated change in phonological form as a possible contributor to the instigation of change in other components of language. Further research with both children and adults with Down syndrome and with those in the general population who show disassociations between competencies in speech and other components of language form is required to identify the motivators and mechanisms of change. Developments in optimality theory and in functional phonology may allow further studies to abstract and compute relationships in the language system while

retaining the link to speech as a tool used by speakers to serve communication needs.

Clinical implications

The gains in all components of language found in group A following a period of indirect intervention suggest that the sharing of detailed information on patterns of linguistic strengths and deficits with parents can result in changes in the environment which facilitate language development. This finding would support the use of parent education programmes to share knowledge and skills with parents but would also suggest that these should be accompanied by detailed information on the current language status of the child. The minimal change in phonological system following indirect intervention compared to that achieved following therapy indicates that indirect generic advice may not be optimal when this component of the language system is impaired. The systematic changes observed in the phonological systems post therapy supports the need for structured programmes to facilitate linguistically based developmental change.

7.3.3. Summary Study 3 Research questions and possible answers

Is accelerated change in intelligibility reflected in changes in the phonological system?

Findings indicated that significant changes occurred in intelligibility levels following therapy in the groups studied. These changes were associated with significant change in all measures of the phonological system.

Are periods of change in phonological systems associated with changes in other components of language?

The results indicated that for this group of children and young adults with Down Syndrome increases in speech intelligibility were positively associated with

developmental levels in general language skills and receptive vocabulary. Relationships between intelligibility and other components of language were weak.

Are there similarities between patterns of change in the phonological systems of individuals with a Down syndrome and those encountered in languages during periods of acquisition and change?

The changes observed in the phonological systems of the participants in the groups reflected the patterns of change seen in typically developing children during the period of early language development. They showed the rapid promotion of faithfulness above markednesss constraints and the majority were reflecting the organisational rules of the ambient language system on completion of the study.

Findings from these studies indicated delays, differences and potential for orderly change in the speech of the participants who presented with low speech intelligibility and impairment of the phonological system. These findings raise questions on how speech impairment in children and adults with Down syndrome might be best viewed.

7.4 Conclusions

These studies explored relationships between low speech intelligibility and language form in order to identify patterns of verbal communication which could merit the label of 'good communicator, poor speaker' for many children and adults with Down syndrome. The literature review identified physical, sensory, cognitive and social factors which could constrain the development of speech and contribute to persisting low intelligibility. The findings of the studies indicated that the children and young adults with Down syndrome who participated showed similar patterns of development and impairments in speech and language to those identified in other studies of this population. They had developed understanding of spoken language and were using the verbal language system to

communicate with others but their development in all components of language form failed to match their achievements in language content and use. They differed from their language age matched peers in a dependence on unmarked forms in phonology, morphology and syntax. They presented with low speech intelligibility associated with phonological systems at variance with the ambient language system. The findings from the studies suggest asynchrony between language skills and speech intelligibility at the onset of formal language development but also indicate the development of a stable code to serve communication functions in many contexts.

The low speech intelligibility was associated with phonological patterns and profiles which did not conform to those observed in typically developing children following the period of formal language development. During development, the participants with Down syndrome showed similar patterns of system organisation in process limitation and suppression and in increasing faithfulness to the ambient language as are observed in typically developing children. However, unlike typically developing children who progress rapidly to full use of the native language system, many children with the syndrome experience protracted periods of development of language form which may foster the adoption and adaptation of early expressive communication systems to meet their communication needs.

The exploration of causative factors, which could contribute to protracted development and stasis in speech development in children with Down syndrome, has been influenced by the ideological and social paradigms which classify variation as delayed or different. Variation from the developmental norms in linguistic development in this population has in the past been classified as either a delay and associated primarily with constraints on social learning and cognition or as a difference and associated with various physical, cognitive or neurological attributes associated with the syndrome.

Those who hold that speech development in children with Down syndrome follows the typical developmental pathways but at a slower pace commensurate

with their cognitive abilities have identified similarities between speech patterns observed in early development and those persisting in the speech of older children and adults with the syndrome. The participants in these studies showed similar phonological elements to those observed in typically developing children at the early stages of formal language development. The use of restricted phoneme inventories, phonological processes and unmarked forms were common to both groups. Their increased prevalence in the participants with Down syndrome contributed to atypical individual profiles which would support those who hold that the traditional slow-but-similar classification of speech impairments in this population is no longer appropriate. The explanatory power attributed to these both the delay and deficit classifications may have masked differences in developmental patterns by shifting the search for causes for the persisting speech impairment to factors external to the linguistic system.

The individual profiles of the participants with Down syndrome in these studies showed significant differences in developmental rates, patterns and phonological system end states. The elements were similar to those encountered in typically developing children during the pre-formal and early formal language stages but their prevalence and use by those who had developed language skills beyond these stages would indicate developmental differences in the organisational rules of the language. These studies identified differences in phoneme inventories, in the number and strength of phonological processes and in constraints against markedness in the individual profiles. The constraints against markedness were reflected in the morphological and syntactic components of language form. The studies also indicated that motor planning or execution difficulties coexisted with phonological impairment in a small number of participants. These could not be explored due to the measures used but it is possible that the application of the formalisms and methodologies from other frameworks could clarify the interaction between perception, production and categorisation in the motor speech act.

The changes observed in the phonological systems of the participants in the third study were characterised by the orderly suppression of processes and the rapid promotion of faithfulness constraints. These systematic changes over a relatively short time frame would not support the attribution of speech impairment to developmental delays in cognitive, social or motor skills. The activation of phonological change, while associated with the general changes in the language and social environments outlined in the previous section, was associated primarily with therapy programmes which focussed on phonological form. The orderly gains seen in the expressive phonologies of the participants appeared to be associated with a non-linear organisational shift in phonological representations and rules. This would suggest that change was motivated and facilitated by the linguistic system and that linguistic constraints could be implicated in the protracted development and impairments of speech and language form in this population.

The early disassociation between language form, content and use observed in the participants in first study would indicate that specific constraints may be operating on phonological development from the early stages of language development. Infants and young children with Down syndrome may experience difficulties in the allocation of resources to the achievement of varying developmental goals. Constraints on auditory acuity and motor skills experienced by many infants with Down syndrome in the first year of life could result in delays or atypical patterns in the development of the phonological foundations for the syllable and word structures of the ambient language. The prevalence of structural processes and the restricted development of syllable structures could indicate that constraints may be operating on the development of receptive or intermodal phonological representations at the preverbal stage. The constraints present during the early language learning period may encourage the modification of linguistic developmental goals and the development of compensatory strategies to facilitate effective message transfer by restructuring language form. The speech of the participants in these studies was characterised by a reduction of marked forms in syllables and segments in the phonological system. A reduction to the unmarked

was also evident in other components of language form in the speech samples obtained from the participants in studies two and three. These were not analysed in detail for the purpose of this study but are reflected in the ratings for expressive morphology and syntax in study three. The adoption of an output code dependent on unmarked forms may be a functional strategy in early childhood but may restrict later development of the language system. Social, linguistic neurolinguistic and cognitive factors may contribute to the maintenance of a code at variance with the ambient language with language use dominating content and form.

The development of an effective spoken communication system is dependent on the integration of language content, form and use both during the initial stages of language learning and throughout the lifespan. Difficulties encountered at any stage may encourage speakers and the language system to develop alternative strategies to facilitate the goal of effective message transfer. The adoption of a modified or unmarked form of the ambient language as the output channel for verbal communication in all contexts may constrain the development of the lexicon and in all components of language form. Children with Down syndrome frequently show disassociation between language content, form and use when they enter the steady language state and these may persist through to adulthood. These may result in further adaptations of the rules of the ambient language and the adoption of a restructured spoken language system to achieve and maintain functional communication in society.

The promotion of constraints against markedness in language form is not unique to those with Down syndrome but is shared by other clinical populations such as those with specific language impairment. Similar systems are also seen in non clinical populations such as late second language learners and those communicating in multilingual contexts. Speakers in all contexts adapt and modify language form creatively to serve communication needs. There are, in general, no assumptions made that the output in these instances indicates a lack

of cognitive or communicative ability and output variations are explored in terms of the structures and processes underlying the language system.

'Good communicators, poor speakers'

Language presents both speakers and listeners with a range of codes for effective message transfer. These range from the concrete code of protolanguage through the representatuional codes of pidgins and creoles to the formal newsreader register of the ambient language. Models to describe code selection and type are numerous and nebulous but most would agree that those who are labelled as good communicators match code appropriately to context and function.

Good communicators may opt for a formal register of the ambient language in some situations but will also draw on their repertoire of informal native language registers and apply strategies to reduce markedness when appropriate. They will be influenced in their choice by the communication context, the message content and the function they wish it to serve. These influences are illustrated in figure 7.

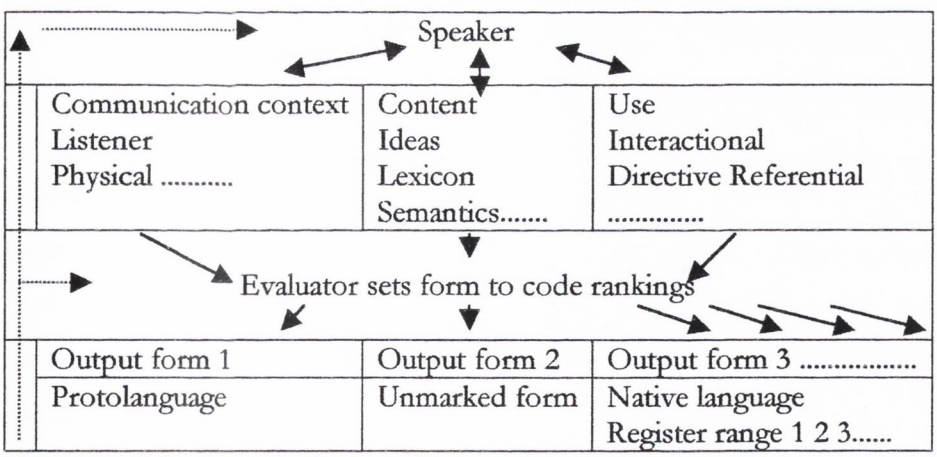


Figure 7. 8 Setting code form

The model suggests that the speaker assesses context, content and function to set the evaluator to the optimal code or functional form currently available to the language system for efficient message transfer. This may result in a code that differs systematically from the native language being deemed optimal in order to maximise communication efficacy.

The selection and use of a speech code that at variance with the ambient language by many children and adults with Down syndrome may serve to maximise communication efficacy in a range of contexts. The participants in the studies presented with low speech intelligibility associated with systematic variation in the phonological, morphological and syntactic aspects of language form. These patterns are similar to those used by flexible creative speakers to merit the label of good communicator in the general population. The consistent use of unmarked codes for verbal communication however places speakers outside the range of form variation acceptable to the community and will thus results in the label of poor speaker.

The cognitive and social constraints on the developing language system experienced by many infants and children with Down syndrome may contribute the setting and the stabilisation of a code based on unmarked forms. The efficacy of these forms for interpersonal communication may reinforce use in many contexts and their stabilisation as a favourite familiar code may block development of the abstract forms required for the use of language as a referential system to serve cognitive and cultural needs.

The findings of these studies suggest that explanations for the persistence in use of phonological systems at variance with the ambient language seen in many with Down syndrome might be more fruitfully explored within frameworks that can accommodate and formalise language variation and change. These explorations are necessary in order to inform and develop effective prevention and intervention programmes to increase the range of communication options available to those with Down syndrome.

Appendix 1.1 Phonological processes

Structural Processes

Label		Description	Example
Unstressed / Weak syllable deletion	USD	Unstressed / weak syllables deleted in multisyllabic words.	banana⇒ nana
Reduction to monosyllables	RM	Multisyllabic words reduced to single syllables.	banana ⇒ na
Reduplication	SR	Syllable or part syllable repeated to replace other syllables in words.	tʌmato⇒mamato
Final consonant deletion	FCD	Syllable final consonants within word or at word boundary deleted.	kʌp ⇒ kʌ
Initial Consonant deletion	ICD	Initial consonants deleted within word or at word boundary	kʌp⇒ ʌp
Cluster deletion	CCD	Clusters of two or more consonants deleted	bɹed ⇒ ed
Cluster reduction	CCR	Clusters of consonants reduced by deletion of one or more consonants	bɹed ⇒ bed
Epenthesis	E	Segment inserted into word - usually between elements of cluster	bɹed > biɹed
Reduction of unstressed syllable	RUS	Unstressed syllable reduced- usually to a vowel	banana ⇒ anana
Replacement of unstressed syllable	USS	Substitution of unstressed syllable by single sound or phonetic shape sound (favourite syllable)	banana ⇒ dənana təmato⇒ dəmato
Reordering of segments (Metathesis/Migration)	MS	Position of two phonemes in word reversed / phoneme migrates to another position in a word	banana ⇒ nanaba

Systemic processes: Place

Fronting De-palatalization	F DEP	Sounds replaced by others produced further forward in the mouth – Subdivided as follows; Palatals fronted-usually to alveolars	 ju⇒lu
Fronting of Velars	FV	Velar sounds replaced by alveolars	kʌp⇒ tʌp
Alveolarization	A	Interdental /Labial sounds replaced by alveolars	fat ⇒ sat
Labialization	LAB	A nonlabial sound is replaced by a labial	ʃu ⇒pu
Backing	B	Front consonants are realised as velars or palatals	ʃu ⇒ ku
Backing +	B+	Front consonants replaced by uvular and / or pharyngeal sounds (fricatives and/or plosives)	ʃu⇒χu; gol⇒ ʔol noz ⇒noɣ
Glottal replacement	GR	Consonants replaced by glottal fricative or stop	ʃu⇒ hu ; noz ⇒no
Systemic Sound preference / Favourite sound	SSP	Replacement of class of phonemes or of several phonemes across class boundaries by a single phoneme.	ʃu su zu tu⇒ bu

Systemic processes: Manner

Stopping	S	Fricatives/ affricates replaced by stops at the same place of articulation	ʃu⇒tu tʃu⇒tu
Affrication	AFF	Fricatives replaced by affricatives [Partial stopping process]	ʃu⇒ tʃu
Gliding Liquids	GL	Liquids replaced by glides	læm ⇒jæm
Gliding other than liquids	GO	Fricatives, etc. replaced by glides	ʃu ⇒wu
De-affrication	DAF	Affricates replaced by fricatives	tʃu⇒ʃu
Nasalization	N	Oral consonants replaced by nasals	ʃu ⇒nu
Denasalization	DN	Nasal consonants realised as oral stops / liquids, etc.	noz ⇒ doz
Lateralization	L	Lateral fricative used in place of forward release in fricatives / affricates	ʃu⇒ɬu
Voicing	V	Voiceless Consonants voiced preceding vowel – Devoiced in final position	ʃu ⇒ ʒu noz⇒nos

Assimilation / harmony processes

Velar Assimilation	VA	Consonants become velarised under the influence of a nearby velar sound	dog⇒gog
Labial Assimilation	LA	Consonants become labialised under the of influence of a nearby labial sound	kʌp⇒ pʌp bed ⇒ beb
Nasal Assimilation	NA	Consonants become nasalized under the influence of a nearby nasal sound.	banana⇒ nanana
Alveolar Assimilation	AA	Consonants become alveolar under the influence of a nearby alveolar sound	bed ⇒ ded
Liquid Assimilation	LiA	Consonants move towards liquids under the influence of a nearby liquid sound.	lɔlipɔp⇒ lɔlilɔp
Vowel Place / manner Assimilation	Vo.P	Consonants influenced by neighbouring vowels in place and manner aspects	lʌv ⇒ lʌz
Prevocalic voicing	PV	Voiceless consonants voiced due to the influence of a preceding vowel	ʃu ⇒ ʒu
Final Devoicing	DV	Final consonants are devoiced as vowels assimilate to silence.	dog ⇒dok

Adapted from Crary, 1993; Dodd 1995; Dodd & Iacono 1989; Hodson, & Paden, 1981; Stoel-Gammon & Dunn 1985: Weiner, 1981.

Appendix 4.1 Managing Intelligibility in Children and Adults with Down syndrome: Summary of project and findings

The project was undertaken in order to determine the effectiveness of phonological therapy for children and young adults with low speech intelligibility associated with Down syndrome. The findings of a pilot project using a modified form of auditory bombardment therapy with young children with Down syndrome (Ní Cholmáin, 1993) resulted in funding being provided to explore the effectiveness of this approach with a larger group by the Dublin Branch of the Down Syndrome Association of Ireland. The project was broadened to include an efficacy component and allow comparison between auditory, cognitive and motor based approaches to phonological therapy. The project aimed to investigate the effects, effectiveness and efficiency of therapy while also obtaining data to explore speech and language variation in children and young adults with Down syndrome.

Forty-six participants were selected to attend for therapy over a thirty-month period. As the programme was designed primarily to explore the effects of auditory bombardment the majority of participants were randomly assigned to this group (22). Twelve participants were assigned to each of the other groups. Changes in these numbers occurred as the project was implemented which limited the findings of the efficacy aspect of the study. The transfer of three participants to local therapy clinics reduced the number of participants originally assigned to the motor skills approach. One participant in this group did not complete the programme for medical reasons. Two participants assigned to the cognitive and one assigned to the auditory approach also failed to complete the programme due to medical reasons. Two participants transferred to the auditory group from each of the other groups due to strong parental preferences. These changes resulted in final group numbers as follows: - auditory n= 24, cognitive n= 10 and motor n=6 which limited the validity of the efficacy component of the project.

The three therapy approaches focussed solely on the phonological systems. The auditory bombardment programme was adapted from the work of Hodson and Paden (Hodson, & Paden, 1983; 1991; Hodson, 1992). This programme aimed to bring about change and reorganisation of the client's sound system by providing controlled information on the contrastive nature of the phonological system using amplification and language routines. It was based on a constructivist approach to development and promoted change by providing the client with structured auditory input on the phonological system and encouraged goal directed imitation using feature directed feedback. The cognitive approach used metaphonological programmes based on Metaphon (Howell & Dean, 1994) which focussed on developing phonological representations at a cognitive level. These programmes encouraged reorganisation of the sound system through developing the client's knowledge of the distinctive properties of speech sounds and their contrastive use to signal meaning. A motor skills programme based on the Nuffield Centre Dyspraxia Programme (Nuffield, 1992) was used to develop neuromotor planning and execution skills. This approach aimed to help the client to achieve mastery of the rapid sequential oral movements required for speech sound production by training the basic movement patterns required for speech at prespeech and speech levels until they are produced automatically.

All programmes were based on individual phonological analysis and used phonological processes and multiple exemplars (Gierut, 1989) in target selection and therapy content. Therapy targets were selected from the client's current phonological system without reference to normative sequences within either the general language domain or phonology. Therapy was provided by a third year speech and language therapy student under the direction and supervision of a professionally qualified speech and language therapist. Clients attended for weekly individual sessions of approximately 40 minutes duration during academic term time. Each participant attended for 20 therapy sessions over a 6 - 8 month period. Home practice was carried out by parents/ siblings on a daily basis.

Therapy outcomes

Effectiveness

All participants showed gains in intelligibility as rated by family members and speech and language therapists following therapy. These changes are summarised in table 1 and illustrated in figure 1.

Table 1 Intelligibility: Pre and post scores

	Auditory	(N= 24)	Cognitive	(N= 10)	Motor	(N = 6)
	Pre	Post	Pre	Post	Pre	Post
Mean	4.92	7.62	3.3	7.7	5.16	7.5
Median	5.5	8	3	8	5.5	7.5
Range	9	5	4	3	2	3
Wilcoxon	P<0.0001	Med.dif.= -2.5	P= 0.002	Med. dif. = -4.5	P=0.0313	Med. dif. = -2.5

The lack of significant change in those who attended for the motor programmes may be attributed to higher baselines and the small number who completed these programme.

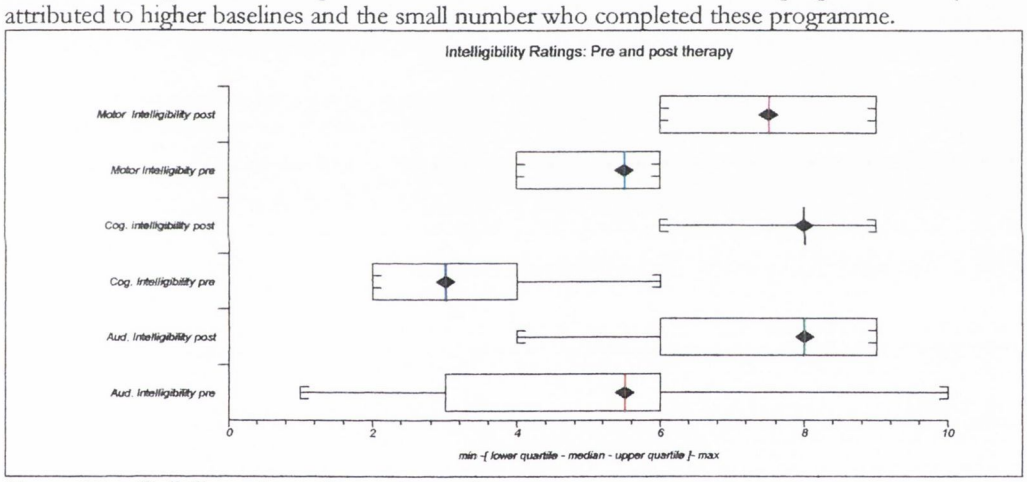


Figure 1 Intelligibility ratings - Pre and post therapy

Systematic changes were evident in phonological systems as indicated by changes in percentage of consonants correct scores summarised in table 2 and illustrated by figure 2.

Table 2. Percentage of consonants correct

	Auditory	(N= 24)	Cognitive	(N= 10)	Motor	(N = 6)
	Pre	Post	Pre	Post	Pre	Post
Mean	49.79	79.25	49.7	74.6	67	80.66
Median	49	84.5	48	71.5	66	82
Range	91	66	71	50	39	39
Wilcoxon	P<0.0001	Med. dif. = -27	P = 0.002	Med. dif. = -24	P=0.0313	Med. dif. = -13

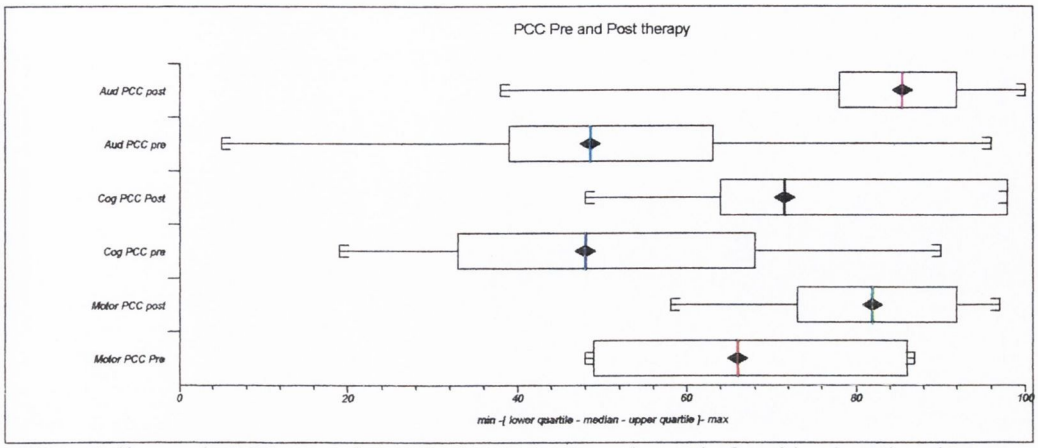


Figure 2 Changes in PCC pre and post therapy in Auditory (n = 24), Cognitive (n=10) and Motor (N = 6) groups.

Changes in the percentage of consonants correct scores indicated that the participants had moved towards the phoneme system of the ambient language following therapy. These changes were seen in both children and young adults across the range of language ages (figures 3-7).

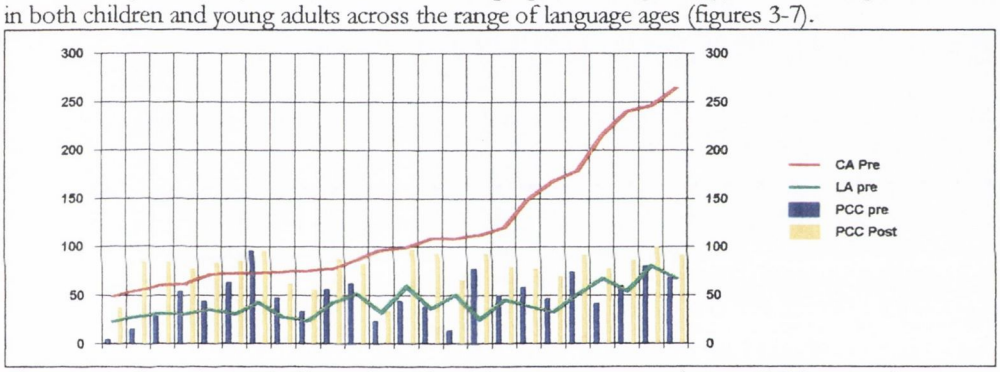


Figure 3 Auditory (n = 24) Chronological and language ages pre therapy, PCC pre and post therapy

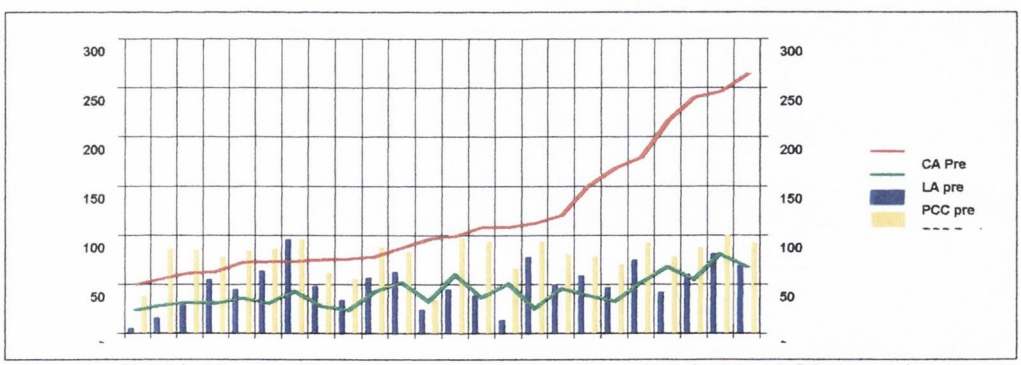


Figure 4 Cognitive (n=10) Chronological and language ages pre therapy, PCC pre and post therapy

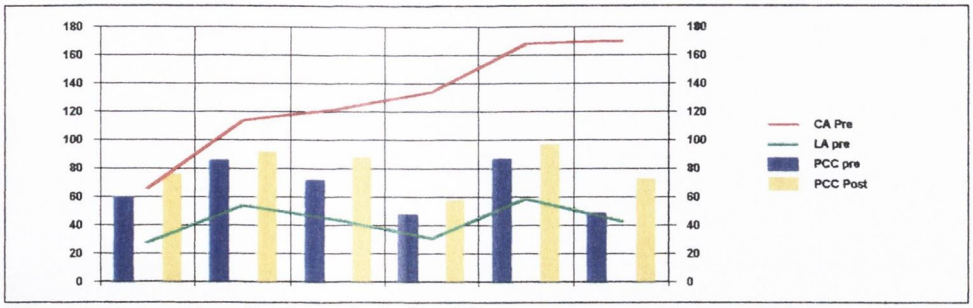


Figure 5 Motor (N = 6) Chronological and language ages pre therapy, PCC pre and post therapy

The changes in intelligibility and in percentage of consonants correct supported the hypothesis that phonological therapy based on individual profiles and targeted at process suppression would facilitate the development of the phonological system in children and adults with Down syndrome and low speech intelligibility. The figures also illustrate the range of language levels and the potential for change at language levels where speech would not be typically selected as a focus for therapy. The finding of changes regardless of chronological age or language level would indicate that caution should be applied if using either to determine eligibility for phonological therapy for those with Down syndrome.

Therapy effects

Systematic developmental phonological change occurred in all participants with a decrease in the number of processes, a reduction in process strength and changes in process type as would be predicted from developmental literature.

Number of processes

All groups showed a decrease in the number of active phonological processes post therapy (figures 6- 8).

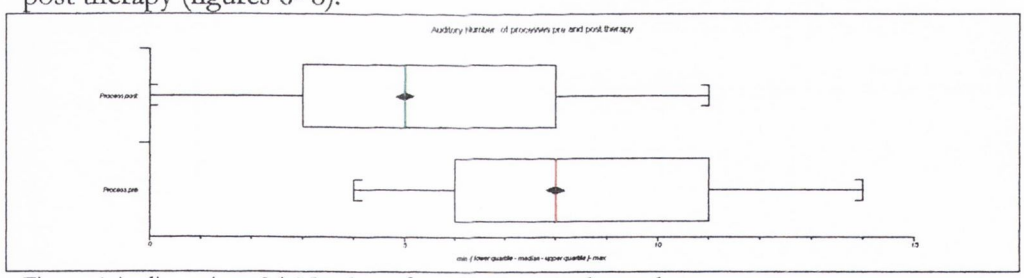


Figure 6 Auditory (n = 24) Number of processes pre and post therapy

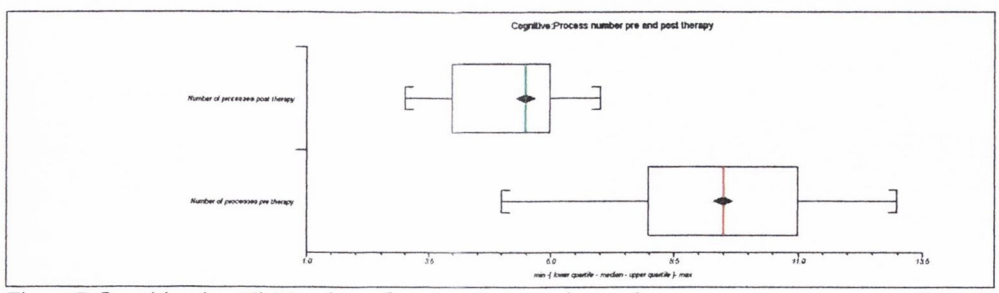


Figure 7 Cognitive (n=10) Number of processes pre and post therapy

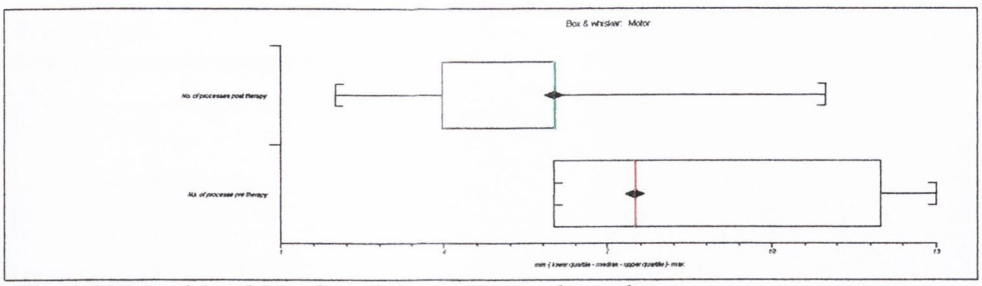


Figure 8 Motor (N = 6) Number of processes pre and post therapy

Process number while providing a measure of global change over the time frame of the study proved to unpredictable as a measure of developmental change during the therapy process with mid point probes indicating an increase in total process number scores as structural process were suppressed and place and manner process emerged.

Process strength

The number of phonemes influenced by each process decreased following therapy in all participants as would be predicted from developmental literature (figures 9-11).

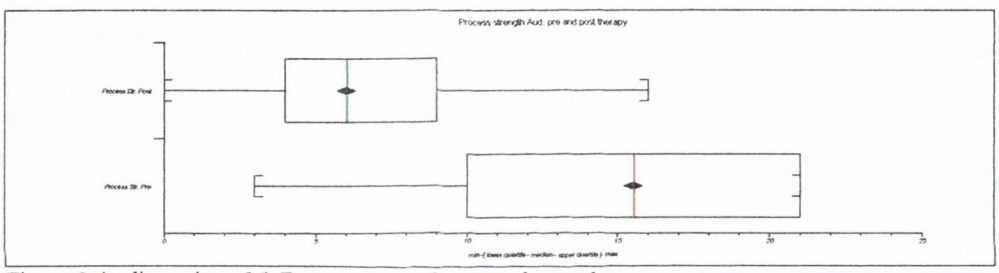


Figure 9 Auditory (n = 24) Process strength pre and post therapy

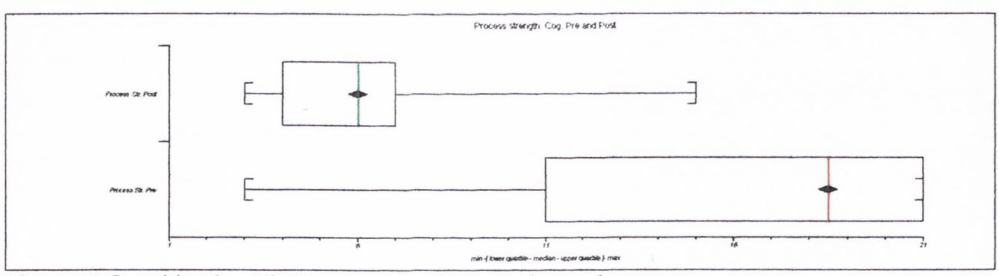


Figure 10 Cognitive (n=10) Process strength pre and post therapy

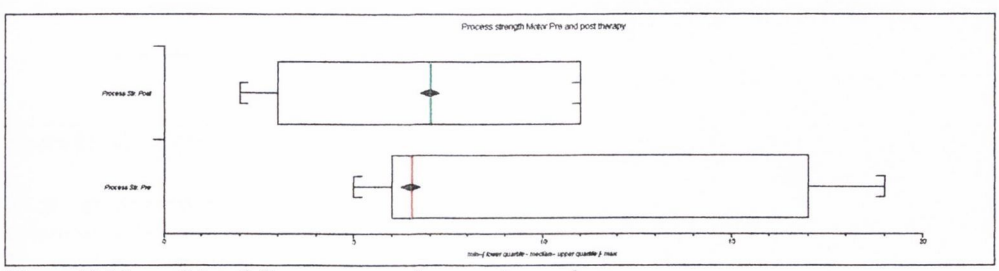


Figure 11 Motor (N = 6) Process strength pre and post therapy

Process type

Changes in process type pre and post therapy occurred in all groups as illustrated in figures 11 –13.

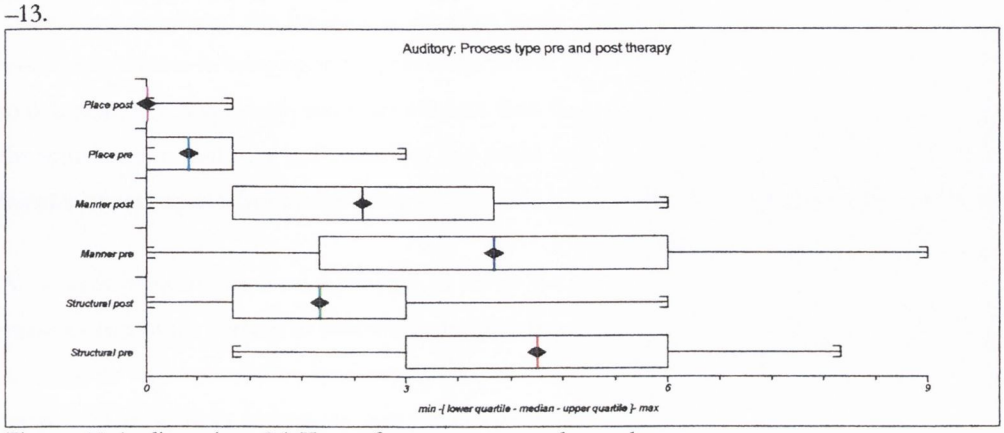


Figure 11 Auditory (n = 24) Type of processes pre and post therapy

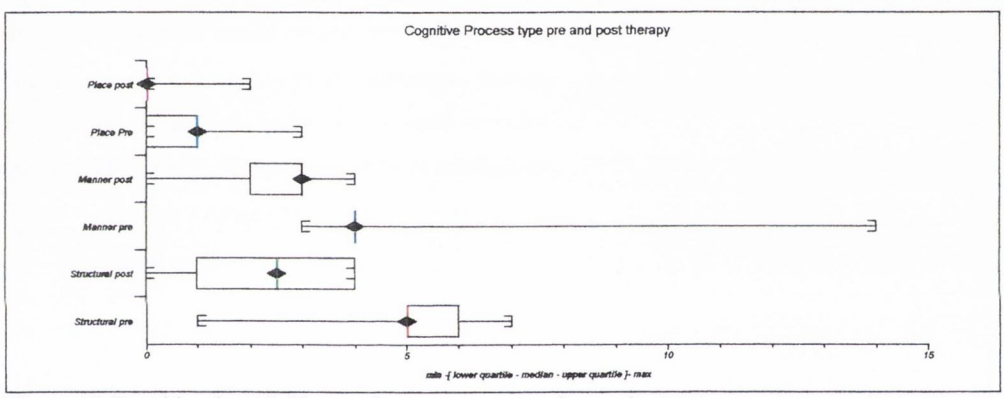


Figure 12 Cognitive (n=10) Types of processes pre and post therapy

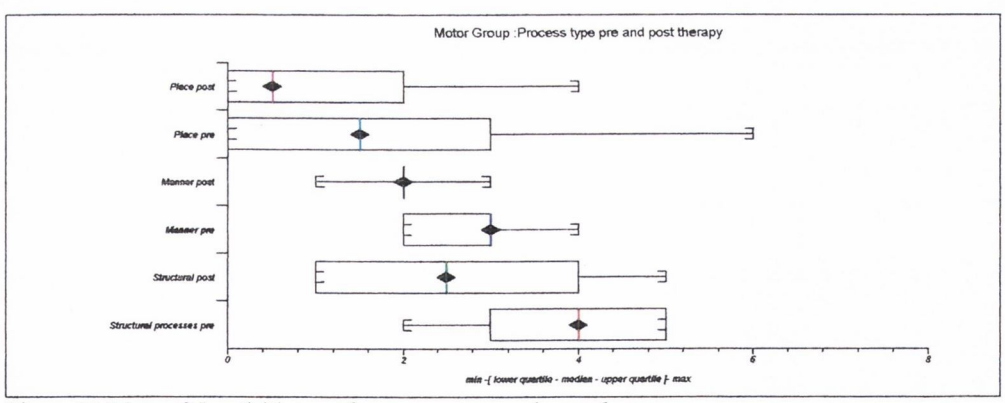


Figure 13 Motor (N = 6) Types of processes pre and post therapy

All groups showed greater decreases in structural processes than in place or manner processes thus reflecting patterns seen in early phonological system development in typically developing children. Place and manner processes decreased in strength in all participants and in many the remaining processes appeared to be in the process of suppression at the end of the study. This could reflect the short time frame of the studies and fact that final measures were taken within 4-8 weeks of therapy completion. Future research would benefit from a longer time frame to verify stabilisation patterns in children and adults with Down syndrome who have experienced low speech intelligibility beyond the typical developmental period.

Efficiency

The project supported the findings of the pilot study in validating the effectiveness of auditory based programmes in bringing about phonological change. It did not provide sufficient reliable data to determine if this approach was more efficient than the motor of cognitive based approaches due the imbalance in numbers and caused by the initial bias in allocation to groups and the loss or transfer of participants from other groups.

All therapy programmes were dependent on carers for implementation and while every effort was made to encourage parents to follow the designated programmes, parental contact in the waiting area and at local association level resulted in an exchange of information on programmes and progress. The auditory programme was perceived by many parents as resulting in greater increases in intelligibility with less effort. This may have influenced programme implementation in the home and future research would benefit from rigorous description and monitoring of therapy delivery. Further research is required to determine therapy efficiency and to identify indicators for appropriate therapy type in the phonological or wider language system. Such research would ideally utilise a wider range of measures of both intelligibility and the phonological system over a longer period and across a range of contexts.

Appendix 4.2 DS group:Application form, communication skills rating scale and consent to treat

Application Form

A. PERSONAL INFORMATION

Name: _____ _____ Date of Birth: _____
Address: _____
_____Telephone:_____
School/TrainingCentre:_____Class: _____

Agencies Involved: _____

B. PREVIOUS SPEECH AND LANGUAGE THERAPY
If your son/daughter has attended for therapy before please complete the following.

1.Where: _____
When: _____
For how long: _____
2 Did therapy focus mainly on
1. General Communication Skills: _____
2. General Language Skills: _____
3. Gestural communication: _____
4. Early Language: _____
5. Speech Sounds: _____
6. Other [please specify]: _____
Specify results: _____
Is your son/daughter currently attending for Speech and Language Therapy: YES/NO

C. COMMUNICATION SKILLS RATING SCALE

Please complete the rating scale by reading across each section and circling the number above the description that best fits your son/daughter.

I. **SPEECH INTELLIGIBILITY**

5	4	3	2	1
Speech is easily understood by others. No major speech sound errors.	Speech understood by others most of the time but some sounds mispronounced	Speech understood by those familiar with the child/ adult only. Many sounds mispronounced	Speech understood by family only. Many sounds mispronounced or omitted	Speech mainly unintelligible. Gestures needed to clarify speech.

II SPOKEN LANGUAGE

A NUMBER OF WORDS REGULARLY USED. How many words does your son/daughter use regularly?

5	4	3	2	1
200 + words	100 + words	50 + words	30 + words	20 + words

B TYPES OF WORDS - What type of words does your son/daughter use regularly?

5	4	3	2	1
Wide variety of all types of words-names action words descriptive words. Location words	Uses names of people, objects, actions & basic descriptive words e.g. big, fast, hot, etc.	Uses names of people, objects & everyday actions	Names of object, people, & some pronouns e.g. I/me/you	Uses names of familiar people, everyday objects & some expressive sounds eg.vroom, vroom for a car.

C TYPES OF SENTENCES - What length of sentence does your son /daughter usually use?

5	4	3	2	1
Uses long sentences (6+ words) with words in correct order. May leave out small words, eg.'the' 'is'	Uses 4+ words together - words in correct order. Asks short questions using question words eg.who, what.	Uses 3 words together. May not have words in correct order.	Uses 2 words together. e.g. ball gone - big ball	Uses 1 word utterances mainly. May use some phrases learned by role, e.g.' bye, see you', 'ready, steady, go'

III UNDERSTANDING OF SPOKEN LANGUAGE

A **VOCABULARY-UNDERSTANDING OF WORDS**

5	4	3	2	1
Wide vocabulary. Understands most words used in the environment	Understands names of people & objects. Understands action words & descriptive words adverbs, ;adjectives.	Understands names of people, objects and routine actions at home and in school / work.	Understands names of familiar people and everyday objects	Understands names of familiar people but needs sit-uational or gestural cues for object names.

B **CONNECTED SPEECH - UNDERSTANDING OF INSTRUCTIONS**

5	4	3	2	1
Can follow detailed instructions containing descriptive or location words	Can follow short directions. Involving objects and actions.	Can follow simple instruction but may need repetition of keywords	Follows instructions if key words are reinforced by gesture or situational cues.	Follows instructions only when given object and key word is repeated

C UNDERSTANDING OF CONVERSATIONAL SPEECH

5	4	3	2	1
Can take part in conversations - listening and taking turns to add information.	Takes part in conversations 3-4 turns each about past, present and future events.	Starts and takes turns in short conversations about objects which are present or ongoing activities.	Takes part in conversation, by answering questions mainly.	Unaware of conversational rules - May not answer questions. Interrupts others etc.

D HEARING: Has your son/daughter a history of Ear infections? **Yes/No**

Intermittent hearing loss **Yes/No** Grommets inserted **Yes/No**

Current hearing level Good _____ Intermittent Loss_____ Regular loss._____

IV USE OF LANGUAGE

A ASKING/REQUESTING - How does your son/daughter tell you when he/she wants something?

1	4	3	2	1
Asks for object using sentences (3-4 words)	Asks using proper name plus some word to indicate need e.g. Gimme, I want.	Asks for it using own name for it	Asks by making sound and using gesture.	Points to the object or its usual location and makes a sound to indicate want.

B REFUSING How does he/she indicate he/she does not want something?

5	4	3	2	1
Says No and gives a reason e.g.. I don't like it	Says No	Shakes head or uses sign plus attempt at saying no	Shakes head or uses gesture or sign	Turns away or ignores

C DESCRIBING/COMMENTING How does your son/daughter describe events to you?

5	4	3	2	1
Uses sentences. Gives a detailed description in logical order.	Outlines people, objects and actions. Order may be confused.	Uses names or people/objects Mimes actions or uses gestures.	Uses names, expressive sounds & mime/gesture.	Shows objects & may act out what happened.

D ANSWERING QUESTIONS When asked a question how does your son/daughter usually answer?

5	4	3	2	1
Uses 2+ words giving appropriate answer	Uses 1-2 word answers	Uses 1 word answer	Uses word or gesture. Answer may be inappropriate	Ignores gestures or answers inappropriately

E ASKING QUESTIONS How does he/she ask you for or about something?

5	4	3	2	1
Uses full question form	Uses question word plus 1-2 other words	Uses question word plus gesture.	Uses gestures facial expression & object/ person name.	Uses facial expression & pointing mainly.

F CLARIFYING/REPAIRING BREAKDOWNS IN CONVERSATION

How does your son/daughter react when people do not understand what he/she has said?

5	4	3	2	1
Repeats word. Tries to articulate with care. Explains word	Repeats word slower. Adds information using speech or gesture	Repeats word & tries to clarify by using gesture or saying word slower	Repeats word 2-3 times and then gives up	Ignores request for clarification or goes on to new topic

II OTHER INFORMATION - Does your son/daughter enjoy the following activities.

Please rate	A little	>>>>>>>>>	A lot
Small Toy Play:			
Imaginative Play			
Rough and Tumble Play			
Turntaking play (ball games, tabletop)			
Listening to music			
Listening to rhymes			
Listening to stories			
Looking at books			
Reading books			
Watching TV			
Other (Please specify)			

Any other relevant information_____

FORM COMPLETED BY _____ DATE_____

PARENT/GUARDIAN_____

MEMBER OF DOWN SYNDROME ASSOCIATION: **YES/NO**

Consent to assess

Parents or guardians who completed application forms received a written outline of the project and a return slip to indicate willingness to attend for detailed assessment and possible participation in the therapy project. The return of the slip was taken as consent for initial assessment.

Consent to treat

The following aspects of the project were discussed with parents and guardians at the initial assessment session in the clinic.

Purpose

- Obtain information on speech development in children and adults with Down Syndrome
- Evaluate the effectiveness of three therapy different approaches to speech impairment

Expected benefits of the study

- Increased knowledge of speech and language development in children with Down syndrome
- Identify efficient and effective ways of working to improve speech intelligibility

Programme outline

Key components of auditory, cognitive, motor therapy approaches outlined and gap in professional knowledge base stressed

- Random allocation to therapy groups auditory, cognitive, and motor – skills
- Therapy delivery by students under the supervision of qualified speech and language therapists
- Commitment needed for 20 sessions of therapy on Mondays or Thursdays and home practice of 20-30 m
- inutes each day

Exclusion

- Persisting severe hearing loss develops or is present at assessment
- Attending for therapy focussed on speech elsewhere.

Use of results

- Individual confidentiality to be preserved and data used in professional contexts
- Recorded materials may be used for educational purposes but individual names will not be disclosed

The older children and young adults were involved in the discussion on commitment to therapy and 'homework' whenever possible. Comments and queries were noted in the clinical file. Parents or guardians were then requested to sign a written consent on the clinical file face sheet which emphasised student involvement, the teaching role of the clinic and the use of audio and visual recordings.

Appendix 4.3: Occupational classification from Data Analysis for Speech and Language Therapy (E.H.B. 1996)

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Occupational Class

Occupational Classification has been based on the International Standards Classification of Occupations (1990). The classification is based on the tasks and duties which constitute an occupation as well as the skill level and specialization required to perform an occupation. The major groups are summarized below.

Skill Levels

The skill levels may be classified in terms of educational categories but ISCO states that the educational status alone should not be used as many of the skills necessary to perform jobs can be acquired through informal training and experience. The skill levels used in the classification are those that can be acquired through formal educational or vocational training.

Skill Level I Primary education generally beginning at 5 - 7 years and continuing for 5+ years.

Skill Level II Secondary Education - two periods:
(a) beginning at 11 / 12 and last 3 years
(b) 14 / 15 years to 17 / 18. May incorporate or be followed by a period of job training.

Skill Level III Education which begins at the age of 17 / 18 and lasts approximately 4 years and leads to a diploma or certificate.

Skill Level IV Education beginning at 17 / 18 and lasting about 4 years and leads to a university degree or the equivalent.

Details of the subgroups and specific job titles can be found in the ISCO (1990) manual.

Group	*Titles*	*Main Tasks / Skills*
1.	Legislators, Senior Officials, Managers	Determining and formulating government policies, laws and regulations. Planning and implementing policies of enterprises and organizations or departments. Skill Level: Multi
2.	Professionals	The application of scientific and artistic theories to the solution of problems. Increasing existing stock of knowledge. Skill Level: 4
3.	Technicians and Associate Professionals	Carrying out technical work in physical life or social sciences or in the humanities. Skill Level: 3

4.	Clerks	Application of knowledge to the organization storage and retrieval of information. Tasks: secretarial duties, recording and computing numerical data, customer oriented, clinical duties. Skill Level: 2
5.	Service Workers, Shop / Market Sales	Providing services related to selling services or goods, i.e. services related to travel, house-keeping, catering, maintaining law and order and direct selling of goods. Skill Level: 2
6.	Skilled Agricultural Fishery Workers	Producing farm, forestry and fishery products and selling products to market. Skill Level: 2
7.	Craft and Related Trade Workers	Knowledge and skills of all stages of production of specialist products. Includes specific trades and handcrafts. Skill Level: 2
8.	Plant and Machine Operators and Assemblers	Operating industrial machinery and equipment including that used for mining, processing, production as well as mobile machinery. Skill Level: 2
9.	Elementary Occupations	Perform simple and routine tasks involving use of physical effort + / - hand tools, e.g. caretaking, cleaning, labouring in mining, construction, fishing, etc. Skill Level: 1
10.	Armed Forces	Those serving in the army, navy or air-force or other military services. (Does not include armed ? occupations, e.g. Garda)

Appendix 4. 4. Intelligibility Rating Scale

Rating	**Parent**	**Therapist**
5	Speech easily understood. No speech sound errors.	Speech fully intelligible. Complete phonological system.
4	Speech understood by others most of the time but some sounds not pronounced correctly and occasional misunderstandings occur.	Generally intelligible. Residual errors primarily in manner e.g. Stopping, Deaffrication, Cluster reduction
3	Speech understood by familiar people when topic is known.	Partly intelligible if topic is known and context shared. Structural and systemic processes present.
2	Speech understood by family only. Many sounds mispronounced and omitted.	Essentially unintelligible. Limited repertoire of consonants used contrastively. Structural processes present.
1	Speech unintelligible. Gestures needed to get messages across.	Unintelligible speech. Gestures and intonation patterns needed to convey meanings.

Appendix 4.5 Phonology probe

Name .....Date of Birth .....Date.....
Tester..... Comments .....

	PROBE				**PROBE + SAMPLE**			
	C to adult system				**C to adult realisation**			**Processes**
Target	S.I.	WwF	WwI	SF	SI	WW	SF	Structural
p								UsD
b								FCD
t								ICD
d								CCD
k								CCR
g								MS
Ø	-	-	-	-				Other
δ	-	-	-	-				
f								Assimilation
v								NA
s								LA
z								Other
ʃ								Systemic P.
ʒ	====		====	-				F
tʃ								B
d3								SSP
m								Other
n								Systemic M.
ŋ	====		====					S
w		====		====				DA
l								GL
r								GO
j		====		====				N
h		====		====				DN
Total								V
Max.	40	44		36				L

P.C.C. = _____ x 100= _____% No. of processes _____
120 No. of phonemes_____

Consonant clusters and polysyllabic words

	S.I.	WW	S.F.	Processes	Polysyllabic
pr			====		football
pl			====		bucket
br		====	====		banana
bl		====	====		buttercup
tr		====	====		tomato
tw		====	====		potato
dr		====	====		butterfly
dw		====	====		helicopter
kr			====		dinosaur
kl			====		octopus
kw		=	====		vegetable
gr		====	====		hospital
gl		====	====		lemonade
gw	=		====		Other:
fr		====	====		
fl		====	====		
sp					
st					
sk					
sw		====	====		
sl		====	====		
sm		====			
sn		====	====		
spr		====	====		
spl		====	====		
str		====	====		
skr		====	====		
skw		====	====		

Phonetic Inventory - Circle sounds in the clients system

Syllable Initial (Word Initial)								Syllable Final (Word Final)						
m			n					m			n			ŋ
p	b	t	d		k	g		p	b	t	d		k	g
f	v	s	z	ʃ				f	v	s	z	ʃ	ʒ	
		θ	ð	tʃ	dʒ				θ	ð		tʃ	dʒ	
w	l	ɹ	j			h			l	ɹ				

PHONOLOGY PROBE

Name: .....Date of Birth: .....

Examiner:.....Date: .....

	Stimulus	*Response*	*Stimulus*	*Response*	*Notes*
p	Pear		Pan		
	Apple		Paper		
	Tap		Soap		
b	Baby		Boat		
	Rabbit		Bubble		
	Bib		Web		
t	Table		Tea		
	Water		Cutting		
	Hat		Light		
d	Door		Dog		
	Ladder		Teddy		
	Bed		Head		
k	Cake		Car		
	Chicken		Cooker		
	Clock		Book		
g	Girl		Gate		
	Jigsaw		Tiger		
	Bag		Pig		
f	Fish		foot		
	Elephant		Coffee		
	Knife		Scarf		
v	Van		Vest		
	Oven		Caravan		
	Sleeve		Five		
s	Sun		Sock		
	Whistle		Seesaw		
	Bus		House		
z	Zebra		Zip		
	Scissors		Razor		
	Cheese		Nose		

	Stimulus	*Response*	*Stimulus*	*Response*	*Notes*
ʃ	Shoe		Shop		
	Washing Machine		Cushion		
	Dish		Brush		
ʒ	Television		Measure		
tʃ	Chair		Chips		
	Kitchen		Teacher		
	Match		Watch		
dʒ	Jumper		Juice		
	Hedgehog		Soldier		
	Orange		Bridge		
m	Milk		Mouse		
	Hammer		Camel		
	Comb		Jam		
n	Nail		Neck		
	Banana		Dinner		
	Man		Gun		
ŋ	Finger		Kangaroo		
	Swing		Ring		
h	House		Hand		
	Keyhole		Beehive		
w	Wall		Window		
	Towel		Shower		
j	Yoghurt		Yard		
	Radio		Yoyo		
l	Lamp		Letter		
	Pillow		Lollipop		
	Ball		Doll		
r	Rain		Roof		
	Carrot		Arrow		
	Ear		Hair		

Consonant clusters

	Stimulus	*Response*	*Stimulus*	*Response*	*Notes*
Pr	Pram		Present		
Pl	Plate		Plane		
Br	Bread		Broom		
Bl	Blocks		Black		
Tr	Train		Track		
Tw	Twelve		Twins		
Dr	Drum		Dress		
Kl	Clothes		Clown		
Kr	Cross		Cry		
Kw	Queen		Penguin		
Gl	Glasses		Gloves		
Gr	Grass		Grapes		
gw			Penguin		
Fr	Fridge		Fruit		
Fl	Flag		Flower		
Sp	Spoon		Spade		
	Crisp		Whisper		
St	Stool		Stamp		
	Duster		Toast		
Sk	Schoolbag		Skipping Rope		
	Basket		Flask		
Sw	Sweet		Swan		
Sm	Smoke		Smile		
Sn	Snow		Snake		
Sl	Slide		Slippers		
Spl	Splash				
Spr	Spray				
Str	String				
Skr	Scrubbing Brush				
Skw	Square				

Appendix 4.6 Process Summary Sheet

Name : _____ **Date of Birth :** _____

Sample Date : _____ **Sample type:** _____

Therapist: _____ **Student :** _____

	PROCESSES	**Phonemes influenced**
	SYLLABLE STRUCTURE	
USD	Unstressed / Weak syllable deletion	
RM	Reduction to monosyllables	
SR	Reduplication	
FCD	Final consonant deletion	
ICD	Initial consonant deletion	
CCD	Cluster deletion	
CCR	Cluster reduction	
E	Epenthesis	
RUS	Reduction of unstressed syllable	
USS	Replacement of unstressed syllable by single sound or syllable	
MS	Moving segments - Reordering of segments A. Metathesis B. Migration	
	Other :	
	Total present	Total influenced:

ASSIMILATION / HARMONY PROCESSES		
	Contiguous assimilation	
	Non contiguous	
VA	Velar assimilation	
LA	Labial assimilation	
NA	Nasal assimilation	
AA	Alveolar assimilation	
LiA	Liquid assimilation	
Vo.P	Vowel place assimilation	
	Prevocalic voicing	
	Final devoicing	
	Other	

SYSTEMIC SIMPLIFICATIONS - PLACE		
F	Fronting	
	De-palatalization	
	Fronting of velars	
	Alveolarization	
	Labialization	
B	Backing	
B+	Backing +	
GR	Glottal replacement	
SSP	Systemic sound preference / favourite sounds	
	Other	
	Total present	Total influenced:

SYSTEMIC SIMPLIFICATIONS - MANNER		
S	Stopping	
AFF	Affrication	
GL	Gliding liquids	
GO	Gliding other than liquids.	
DAF	De-affrication	
N	Nasalization	
DN	Denasalization	
L	Lateralization	
V	Voicing	
	Other	
	Total present	Total influenced:

	Unusual processes	Phonemes

Examples of Phonemes Affected by two or more Processes / process ordering

Appendix 4. 7 Word and syllable imitation - Stimulable sounds

Name: ..... Date: ..... Tester: .....

Have child imitate the single phonemes in a sound making game. Then add /a/ and have him/her imitate the syllable. Test imitation of words later in the assessment session.

	Sound	Syllable Response	Word / syllable initial	Response	Word /syllable final	Response
p			pea		cup	
b			bee		bib	
t			tea		hat	
d			do		bed	
k			key		book	
g			go		bag	
f			foot		roof	
v			van		five	
s			sea		house	
z			zoo		nose	
ʃ			shoe		wash	
tʃ			chair		watch	
dʒ			jam		bridge	
m			me		comb	
n			no		pen	
ŋ			-------		ring	
h			head		-------	
l			leaf		ball	
ɹ			run		car	
j			you		--------	

If the child has difficulties in imitating, repeat the stimulus using toys or pictures or adding vocal, visual and verbal prompts. Comment on which of the following was helpful in producing accurate imitation.

Changes in pitch, stress volume of stimulus	
Visual cues	
Verbal prompts	
Symbolic association	

Appendix 4.8 **OROFACIAL EXAMINATION**

Name:_____ Date: _____ Assessed by:_____

1ORAL STRUCTURES

A		Symmetry	Note deviations
Nose			
Lips			
Teeth			
Palate			
Velum			

B Dentition: Type primary ☐secondary ☐ Occlusion normal ☐ abnormal☐
Notes: _____

C Palate Shape: high ☐ normal ☐
Note cleft, repair, fistulae: _____
D Velum: size _____
Tonsils: appearance (note if inflamed /enlarged): _____

F. Tongue: size _____

Note atrophy / fasciculation, etc _____

2 STRUCTURE RATING

	0 Non significant		1 Mild deviations		2 Severe deviations

(2) FUNCTION

A Lips: Imitation of pursing: _____
Imitation of retraction: _____
Imitation of /u -i/ x 3: _____
Note Lipseal _____

Lip tone normal ☐ increased☐ reduced ☐

B Tongue: Imitation of protrusion: _____
Imitation of retraction: _____
Imitation of elevation: _____
Imitation of depression: _____
Imitation of lateral movements: _____
Imitation of circular movements _____
Repeat /læ læ/ x 3☐

C Velum: elevation /æ/ _____
Note adequacy of closure / symmetry _____

D Breathing

Note whether habitual mouth/nose breathing _____

Place of breathing: Upper thoracic ☐ Abdominal ☐ Mixed ☐ Reversed ☐

Note rate and adequacy: _____

2 Function Rating

	0 Non significant		1 Mild deviations		2 Severe deviations

(3) SPEECH MOVEMENT SCREENING

a Bilabial plosives:	imitate	/p p p/	☐
	imitate	/b b b/	☐
b Alveolar plosives:	imitate	/t t t/	☐
	imitate	/d d d/	☐
c Velar plosives: imitate		/k k k/	☐
	imitate	/g g g/	☐
d Rapid sequential movements:	imitate	/p t k/ x 3	☐
	imitate	buttercup x 3	☐

3 Movement Rating

	0 Non significant		1 Mild deviations		2 Severe deviations

Overall evaluation

0 no significant findings ☐

One mild deviation / difficulty evident ☐

2 severe deviation / difficulties evident ☐

Further investigation necessary _____

Further referrals necessary _____

Implications for therapy:

Appendix 5.1 Participants Study 1 Descriptive summary

Study 1 Participant characteristics and scores on language and speech measures

Down Syndrome (DS) group						Typically developing (TD) group				
		CA (Months)	LA (Months)	Int. rating	PCC		CA (Months)	LA (Months)	Int. Rating	PCC
1	M	50	24	1	5	M	24	26	8	88
2	F	51	27	4	45	M	24	24	8	78
3	M	52	33	1	10	M	28	25	8	73
4	M	53	30	2	22	M	30	28	10	100
5	F	54	25	2	23	M	31	29	9	85
6	M	54	24	1	3	M	33	28	9	93
7	M	55	24	1	19	M	32	25	9	91
8	M	56	29	1	16	M	35	30	8	83
9	M	61	32	2	29	F	34	31	8	90
10	M	61	32	2	19	F	35	35	10	100
11	M	61	32	1	19	F	35	30	6	83
12	M	62	38	2	32	M	36	35	9	96
13	F	62	29	4	65	F	37	31	8	88
15	F	63	26	3	46	M	37	30	10	100
16	F	63	26	3	19	M	38	29	9	91
17	M	64	24	4	26	F	38	34	8	92
18	F	62	36	6	61	M	38	33	10	100
19	M	72	36	5	45	F	38	30	9	91
20	F	74	42	6	69	F	38	37	10	100
21	M	85	24	2	17	F	38	37	10	100
22	F	87	41	3	54	F	40	37	10	100
23	F	87	41	7	80	M	41	36	10	100
24	M	96	24	2	20	F	42	42	6	81
25	F	97	39	8	81	M	44	42	8	98
25	F	99	24	4	45	M	45	39	10	100
26	M	102	24	6	93	M	46	39	8	78
27	M	103	33	2	13	F	48	36	8	94
28	M	105	36	7	43	F	50	38	10	100
29	M	107	33	4	20	M	52	38	10	100
30	M	108	37	4	39	F	52	38	10	100
31	M	115	42	5	53	M	72	42	10	100
32	M	120	33	4	23	M	58	40	9	85
33	M	138	34	6	31	M	57	41	6	85
34	F	149	33	6	80	M	50	40	8	90
35	F	168	33	4	47	M	52	41	10	100
36	M	171	31	6	69	F	52	42	8	92
37	M	174	35	1	29	F	48	33	6	96
38	M	198	42	4	60	M	52	38	6	92
39	M	78	43	6	57	M	40	44	9	98
40	F	87	52	7	63	M	45	54	10	100
41	F	87	48	6	82	M	48	46	10	100
42	M	92	45	2	58	M	50	45	8	96
43	F	95	48	6	42	F	51	49	9	98
44	M	98	48	4	37	M	52	48	8	86
45	M	99	60	6	45	M	52	56	10	100
46	F	102	48	5	77	M	58	60	10	100
47	F	108	51	4	14	M	58	56	10	100

48	M	120	46	6	50	F	65	55	10	100
49	M	122	44	5	72	F	52	52	10	100
50	M	152	59	8	74	M	53	44	10	100
51	M	161	52	8	81	M	56	50	10	100
52	M	170	43	6	49	M	71	46	10	100
53	F	172	48	6	55	M	67	44	10	100
54	M	172	52	4	45	M	81	43	10	100
55	M	179	52	8	75	F	75	60	10	100
56	M	179	49	8	75	F	64	48	10	100
57	F	180	45	3	61	M	59	59	8	92
58	M	189	60	8	81	M	59	60	4	85
59	M	216	46	6	20	M	53	48	8	90
60	M	216	48	8	86	M	48	52	10	100
61	F	216	48	7	88	M	56	49	10	100
62	M	218	60	6	71	M	53	46	9	95
63	M	228	54	5	48	M	54	52	10	100
64	M	234	60	8	83	F	52	44	9	92
65	M	240	56	6	82	F	51	43	9	80
66	M	288	52	6	69	F	48	47	10	100
67	M	252	54	8	66	F	64	60	10	100
68	M	120	76	7	80	M	65	64	10	100
69	F	122	76	6	81	M	64	64	10	100
70	F	150	77	8	72	M	63	64	10	100
71	M	156	59	6	69	M	68	64	10	100
72	F	168	64	4	47	F	70	61	10	100
73	M	246	81	6	81	F	50	64	10	100
74	F	246	72	8	76	F	62	61	10	100
75	M	264	68	10	93	F	98	84	10	100

Appendix 6.1 Participant characteristics: Study 2 and Study 3 (Time 1)

		CA*	LA*	Int. rating	PCC	Process number	Process strength	System rating	Group
1.	F	51	27	4	45	11	21	5	A
2.	M	50	24	1	5	14	21	8	B
3.	F	54	25	2	23	12	18	9	A
4.	M	56	29	1	16	6	14	6	B
5.	M	61	32	2	29	6	21	6	B
6.	M	61	32	2	19	8	18	8	B
7.	F	62	36	6	61	7	14	4	A
8.	F	62	29	4	65	14	21	6	A
9.	F	63	26	3	19	12	21	7	B
10.	M	63	26	3	46	13	16	7	A
11.	M	64	24	4	26	15	18	6	A
12.	M	72	36	5	45	8	21	6	B
13.	M	78	43	6	57	10	14	5	B
14.	M	85	24	2	17	12	21	7	A
15.	F	87	41	7	56	8	14	5	A
16.	F	87	52	7	63	7	15	4	B
17.	M	92	45	2	58	5	11	7	A
18.	M	96	24	2	20	10	21	6	A
19.	M	99	60	6	45	4	13	5	B
20.	M	102	24	5	63	8	9	6	A
21.	M	102	48	5	77	6	7	4	A
22.	M	105	36	7	43	7	7	5	A
23.	M	107	33	4	20	7	21	6	A
24.	M	108	37	4	39	4	21	6	B
25.	F	108	51	4	14	6	21	7	B
26.	M	120	33	2	13	8	13	9	A
27.	M	120	33	4	23	7	21	6	A
28.	M	120	46	6	50	5	18	7	B
29.	M	122	44	5	72	8	4	6	B
30.	M	138	34	6	31	9	18	6	A
31.	F	149	33	6	80	7	9	3	A
32.	M	156	59	6	69	7	13	5	A
33.	F	168	33	4	47	9	21	6	B
34.	M	170	43	6	49	6	12	4	B
35.	M	179	52	8	75	5	8	3	B
36.	F	180	45	3	61	5	8	3	B
37.	M	216	68	6	42	8	15	6	B
38.	M	228	54	5	48	7	14	5	A
39.	M	246	81	6	81	6	7	4	B
40.	M	264	68	10	69	5	6	5	B

Ages in months

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