FACTORS THAT INFLUENCE THE LANGUAGE AND COMMUNICATION OF HEARING-IMPAIRED CHILDREN

TINA W. RAMKALAWAN, BSC

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ABSTRACT

Studies have shown that permanent childhood hearing impairment can have detrimental consequences for spoken-language development. It is widely accepted that early detection and intervention may improve outcomes for profoundly hearing-impaired children. However, few studies evaluate the influence on the families or give particular attention to children with mild-to-severe hearing impairments.

This research used spoken language and communication to focus on a range of factors that may influence outcomes for children with permanent sensorineural hearing impairments. In two studies, children with a range of hearing impairments, aged 32 to 85 months (mean = 63, s = 14) were audio- and video-recorded at home interacting with a major care-giver. Measures of spoken language for the children and their interlocutors were derived from transcripts. Controlling for the age of the child, spoken-language outcomes were evaluated in relation to factors such as the severity of the child's hearing impairment, age of intervention and the language addressed to the child during the interaction. The first study indicated that hearing severity, excluding profound hearing impairments, may not be the most important influence on spoken language. However, earlier intervention corresponded to better language performance. The second study failed to replicate these findings but suggested that a complex interaction of factors – including earlier referral for hearing assessment – may influence spoken language production for hearing-impaired children.

Questionnaires revealed the families' attitudes and feelings towards the diagnosis[1] of their child's hearing-impairment, showing that parents often experienced negative emotions at the time and that intervention provisions often fail to take parental attitude into consideration at this time. Results also suggested that earlier and prompt intervention for childhood hearing-impairment is viewed as beneficial and essential. This may have important implications for habilitation and intervention programmes for hearing-impaired children and their families. The conclusions suggest that further

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[1] Throughout this thesis, 'diagnosis' refers to the time at which the child's hearing impairment was initially confirmed following formal audiological assessment.

studies – which evaluate and detail the potential long-term benefits of very early intervention for hearing-impaired children – need to be conducted.

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This is dedicated to my parents who have made everything possible for me.

"*Without education, you are not going anywhere in this world*" Malcolm X, May 29, 1964.

Note on Appendix:

The published article presented in the Appendix is work undertaken during my period of PhD study and is directly related to the contents of this thesis. Adrian Davis is included as a second author as he provided help and advice on the presentation of the results section and commented on earlier drafts of the paper. The main parts of the writing and data presentation are my own work, as are the contents of this thesis in its entirety.

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CHAPTER ONE

CHAPTER ONE

GENERAL INTRODUCTION

Early identification has increasingly become an important and popular concept in child health development, both in terms of services provided and the research which has been conducted to support service' developments and improvements. Paediatric hearing research is no exception (Hall, 1991; 1996). The focus of work in this area has been on early detection in the neonatal population. As such, investment in technological improvements continue with an aim to detect hearing impairment as early as possible, with improved sensitivity and specificity. Researchers are even aiming to push the point of detection back into the womb (Shahidullah & Hepper, 1994; Hepper & Shahidullah, 1994; Kemp, 1992). Central to arguments for the provision of neonatal hearing screening programmes is a belief that the early detection of hearing impairment and the provision of efficient follow-up services and intervention will help to minimise disadvantage for hearing-impaired children.

However, the evidence for this belief is sparse and it is not clear whether early detection is to the advantage of all permanently hearing-impaired children. Furthermore, while it is taken as axiomatic that early detection is good for severely/profoundly hearing-impaired children, this assumption is not as readily made for those children with mild or moderate hearing impairments.

One consideration is the difference in post-identification needs that children with mild-to-moderate hearing impairments may have in contrast to children with severe-to-profound hearing impairments. For a child with a hearing impairment, intervention may focus on minimising the detrimental impact of the actual hearing impairment (e.g. via amplification/hearing-aid provision, cochlear implantation) or may focus on improving the family and child's ability to manage the impairment. The choice of post-identification interventions will be influenced by the degree of hearing loss detected, as well as the range of follow-up services available to the child and his/her family in the particular district in which they live.

Over the last two years, age of identification has been lowered for profound hearing impairment (Davis et al., 1995). This in turn has led to earlier intervention for children in this impairment category. Even the most profoundly hearing-impaired children, who may have little to gain from early amplification, have been shown to benefit from early intervention programmes (Greenberg and Calderon, 1984). In addition, successful results with tactile aids (Steffens, Eilers, Fishman et al., 1994) and with early cochlear implantation of congenitally impaired children (Waltzman & Cohen, 1994) indicate areas of potential benefit for this group should they be identified earlier.

Few comparable findings have been presented for children that have mild-to-moderate hearing impairments in terms of improvements in age of detection. Therefore, the potential benefits of early detection for these children are not as clear. It may be argued that children with mild-to-moderate hearing-impairments have less to gain from early detection as many of them may learn to make good use of their residual hearing early on, with minimal primary intervention (e.g. hearing-aid provision). Kretschmer and Kretschmer (1978) suggest that early amplification in these instances may possibly serve to distort the input that is received through residual hearing.

Alternatively, others suggest that children with mild-to-moderate hearing impairments may be as potentially disadvantaged by late detection as those with severe-to-profound hearing impairments. Evidence from a study examining the effects of early intervention programmes on hearing-impaired children's language development, suggests that children with mild-to-moderate impairments may stand to gain more from early detection than their profoundly hearing-impaired peers (Strong, Clark and Walden, 1994). Ordinarily, the negative consequences of mild-moderate hearing impairments may go largely unnoticed until early to mid-childhood when language delays prompt referral for hearing examination. As a result, some researchers have suggested that the implementation of neonatal screening programmes which assess all children for hearing loss may be particularly to the advantage of those with mild-to-moderate hearing impairments. It is these children who may have more to gain in terms of improvements in age of detection (Harrison & Roush, 1996).

Intuitively, it seems likely that most hearing-impaired children will benefit from early identification, regardless of the level of their hearing impairment. However the question still remains as to how early detection should be. It is of course possible that *very* early detection, at 24 hours or earlier, may not be demonstrably better than identification by six months postpartum. Decisions will in part be influenced by an understanding of development and plasticity during these early periods of life. In addition, any potential benefits will hinge to some degree on the efficiency, efficacy and nature of services provided post-identification, as well as on the family response and attitude to the child's impairment. Therefore, any evaluation of benefits needs to take these, and related factors, into consideration. There may also be benefits of early detection which lie in domains less easy to quantify and evaluate, but which may nevertheless impact enormously on the nature of outcomes for hearing-impaired children.

The potential benefits of early detection for the child may lie in the family being informed early that the child is hearing-impaired, which may in turn enable them to seek appropriate advice and guidance. Other benefits may involve the child being given appropriate amplification, speech therapy and additional educational support, and being exposed to sign language or speech early, before language production begins. There are also potential benefits for the family which may impinge directly or indirectly on benefits for the child (Gunther, 1994). These may include the family acquiring information and knowledge about the hearing impairment which in turn may aid acceptance of the impairment (in the case of hearing families). Techniques for appropriate communication strategies may also be introduced along with sign language and an increased awareness of deaf culture.

Another consideration that arises, if the potential benefits of early detection are to be continuously evaluated, is how benefit might be measured. Some form of outcome measure(s) needs to be chosen, preferably one(s) which can be quantified with some degree of consistency.

One suggestion is to focus on outcomes which may be of significance for the child's development (cognitive, psychological, educational) and to establish a method of measuring these (reliably). These outcomes can then be evaluated in relation to age of identification. It will also be important to ascertain the quality of the benefits received from both the child's perspective and that of the family. This may become increasingly important in the future as Quality of Life measures permeate further into a financially deprived healthcare sector.

Some outcome measures which could be used relate to language acquisition and cognitive development, social and communication skills, and Quality of Life evaluation. In the long term, educational attainment, psychosocial adjustment and career management may serve as useful indicators.

This research attempts to address some of the questions and points highlighted above. The potential benefits of early detection were evaluated by focusing on spoken language and communication as outcome indicators of one possible area of benefit for the child. Family attitude to services provided and response to the confirmation of hearing impairment was also ascertained with the use of questionnaires. The effects of early detection on mild-to-severely hearing-impaired children in comparison to profoundly hearing-impaired children were also considered. The first chapter introduces some background issues relevant to the research.

1.1 HEARING IMPAIRMENT IN CHILDHOOD

1.1.1 MAIN CAUSES OF CHILDHOOD HEARING IMPAIRMENT

Childhood hearing impairment can take several different forms. Amongst the main characteristics which broadly define the type of hearing impairment that an individual may have are the following: The hearing impairment itself may be congenital or acquired and fall into one of two main categories – sensorineural or conductive. Sensorineural hearing impairments are permanent and irreversible, whereas conductive hearing impairments can be transient. Often children with sensorineural hearing impairments may also have an accompanying conductive element as acquired conductive hearing loss is very common during childhood.

Congenital versus acquired hearing impairments

A congenital hearing impairment is one which is present at birth and an acquired hearing impairment is acquired after birth. One main cause of congenital hearing loss is genetic inheritance, although the cause remains unknown in a large number of cases (Newton, 1985). Acquired hearing impairments may occur peri- or post-natally, as a result of infection (e.g. bacterial meningitis), through trauma to the head or ear (e.g. via the early administration of certain drugs – e.g. gentamycin) or as a result of oxygen deprivation during birth (anoxia). In recent years however, progress has been made in reducing the number of childhood hearing impairments acquired as a result of bacterial meningitis and toxoplasmosis (Stein & Boyer, 1994).

The majority of **permanent** childhood hearing impairments are congenital and sensorineural, while there is a high incidence of acquired transitory conductive hearing loss in young children (between ages 1 and 6 years). In a very small number of cases, severe acquired conductive hearing impairment can result in permanent sensorineural auditory dysfunction (Marr, 1992).

Sensorineural hearing impairment

Sensorineural hearing impairments typically involve dysfunction in the cochlea, the auditory nerve and/or the auditory pathways leading from the auditory system to the brain.

Although sensorineural hearing impairments can be congenital or acquired, the majority of childhood sensorineural hearing impairments are congenital and are genetically determined. It is estimated that in over 50% of genetically-determined cases the cause of hearing impairment lies in the inheritance of an autosomal-recessive patterned disorder. As such, parents are often not themselves hearing-impaired, but are both carriers of recessive genes that may cause sensorineural hearing impairment in their offspring. Thus, the majority of children with this type of hearing loss are born to hearing parents. Autosomal dominant and X-linked inheritance account for the remaining cases in this category. Other causes of sensorineural hearing impairment include rubella (infection of mother during pregnancy) and ototoxic drug intake during pregnancy which can damage the fetus' developing cochlea.

Conductive hearing impairment

Conductive hearing impairments are far more common and typically involve some form of mechanical dysfunction in the outer or middle ear. In this type of hearing impairment, sound is unable to travel normally, via conduction, through the outer ear and/or across the middle ear. Conductive hearing impairments can be congenital or acquired, although the most common form of childhood conductive hearing impairment (otitis media) is acquired. In the case of otitis media, middle ear ventilation, via the Eustachian tube, is disrupted, causing a build up of negative pressure behind the tympanic membrane in the middle ear cavity. This often results in the cavity becoming fluid-filled and normal sound conduction is thus hampered. Treatment can be surgical, such as the insertion of grommets, which seeks to aerate the middle ear cavity through the tympanic membrane. Alternatively, non-surgical interventions, such as antibiotics, may be prescribed in the first instance to target infections which may have caused or be exacerbating symptoms.

As well as differences in causes, there are a number of differences in prognosis and outcome for children with congenital and for children with acquired hearing impairments. Some of these differences will be considered in later sections of this chapter.

The epidemiological data forms an important context for any work with hearing-impaired children and this is reviewed in the next section.

1.1.2 EPIDEMIOLOGY OF HEARING IMPAIRMENT IN CHILDHOOD

The majority of permanent hearing impairments in children in Britain are congenital (present at birth) or early-onset genetically determined. However, accurate prevalence rates for these are difficult to determine, with estimates often ranging considerably (Dias, 1990). Some of the problems which contribute to this difficulty are succinctly highlighted by Davis (1994), who reviews the area and notes that determining prevalence estimates is complicated by a number of factors. These include the lack of standard definitions used to reference and identify populations (e.g. deaf, profoundly deaf), varying population mobility rates which affect the reliability and comparability of estimates across different districts, and variations in the employment of hearing assessment procedures. Estimates for mild and moderate hearing impairments are also particularly unreliable, and the complicating factor of fluctuating intermittent hearing loss is not consistently taken into consideration. In addition, prevalences are more often than not calculated using retrospective estimates, as opposed to prospective ones, which in itself may render differences[1].

After reviewing the various prevalence estimates that have been put forward by researchers for different districts in Britain, and taking into consideration the above factors, Davis estimates that nationally 1 in 2000 children aged five years may have a severe-to-profound hearing impairment (equal to or above 80 dB HL). If moderate and severe hearing impairments are also considered, in other words if all hearing losses between 50 and 80 dB HL are also included, this prevalence rate rises to 1 in

[1] Retrospective studies obtain information relating to participant' factors from past case notes or records. Advantages are that a higher sampling fraction of cases can often be taken and that relevant information can be obtained comparitavely quickly. Prospective studies follow the study-population in time and monitor factors of interest as they occur. While administratively more complex, an advantage is that information can be obtained directly and more reliably related to co-occuring factors of interest.

770 children. The prevalence estimates for children with mild hearing impairments (i.e. less than 50 dB HL) become even more difficult to determine, especially as many of these children are often not detected until later than those with more severe impairments.

For the purposes of this thesis, it is useful to consider the prevalence rates provided by Davis and Wood (1992) which were based on a 1983 to 1986 birth cohort in the Nottingham district health authority (DHA). This encompasses the population from which the participants of the research were selected. Davis and Wood used average hearing threshold levels over the mid-frequency region (0.25 – 4 KHz) and calculated a 0.4 in 1000 (C.I.= 0.3 – 0.5) prevalence rate for profound childhood hearing impairment[1]. They estimated 1.8 in 1000 children in the population to have been fitted with a hearing aid by the age of five (C.I. = 1.4–2.3). Estimates for moderate hearing impairments were not included in this study.

However, a later study (Davis, Wood, Healy et al., 1995) encompassed birth cohorts (1983 to 1988) from the Oxford, Nottingham and Sheffield district health authorities in addition to the one used previously from Nottingham and found estimates of 1.0, 1.5 and 1.9 (per thousand) for impairments of 40 dB HL and above, for each district respectively. The overall estimate was 1.2 per 1000 (C.I. = 1.1–1.4). While the different prevalence estimates in themselves illustrate problems with the comparability of data across districts, it is strongly suggested that a lower impairment baseline (e.g. 25 dB HL) would lead to an increased prevalence estimate.

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[1] All sensorineural/mixed and progressive congenital hearing impairments.

1.1.3 RISK FACTORS FOR PERMANENT CHILDHOOD HEARING IMPAIRMENT

It is estimated that around 50% of hearing-impaired children exhibit risk factors for hearing impairment in their medical histories (Arnold, Schom & Stecher, 1995). Family history is recognised to be an important risk factor for congenital hearing impairment. Sixteen percent of children in the Nottingham DHA are estimated to have family history as the sole indicator of hearing impairment, while estimates for wider populations place the incidence of family history as a risk factor at around 19% (Gerber, 1990; Wood et al., 1994).

There has been considerable development in the study of genetically determined hearing loss over recent years. In a study conducted by Newton (1985), hereditary factors were found to account for 30% of cases of mild-to-severe hearing impairment in a group of 111 children in the Greater Manchester region. This was the largest category of known causes of hearing-impairment. Congenital rubella accounted for 11% of cases and 44% of cases had unknown causes. While advances have been made in the mapping of gene loci for Usher[1] and Waardenburg[2] syndromes, mapping of the specific loci of genes for inherited disorders which may cause hearing loss are still to be determined in many cases. The heterogeneous nature of some of the more commonly implicated syndromes is a complicating factor (Trop, Schloss, Polomeno et al., 1995), as is the difficulty of distinguishing sporadic genetic cases from cases of hearing loss acquired early as a result of prenatal or perinatal environmental causes. In many instances, report of a family

[1] Typical signs are retinitis pigmentosa, and congenital sensorineural deafness.
[2] Typical signs are sensorineural deafness, laterally displaced medial canthi, broad nasal root, white forelock, and heterochomia iridis.

history of congenital hearing impairment is an important indicator that the child may be at risk for hearing loss.

Another important risk factor for permanent childhood hearing impairment is whether a child receives intensive care following birth.

NEONATAL INTENSIVE CARE

It is well documented that infants who receive neonatal intensive care are at increased risk for a range of developmental, neurological and sensory disorders.

One risk factor common to neonates in intensive care is that of prematurity (defined as < 2.5 kg at birth) and low birth weight. In a comprehensive study incorporating children in the Nottingham DHA, Davis & Wood (1992) found that, excluding all known relevant syndromes and cases with a family history of hearing impairment, a child graduating from the Neonatal Intensive Care Unit (NICU) was over 8 times more likely to have a hearing impairment that a non-NICU graduate. In a prospective study of a very low birthweight population, Weisglaskuperus, Baerts, Degraaf, et al. (1993) found that 42% of the children studied had some form of mild-to-severe hearing impairment – although details were unspecified as to the types of hearing-impairment found. Alternatively, Veen Sassen, Schreuder et al. (1993) report conductive hearing loss in 14% and sensorineural loss in 1.5% of the children (who had all been NICU-graduates) in their study, as assessed by pure tone audiology. A large body of research draws attention to the increased risk of these children for sensory, physiological and spatial dysfunction, as well as possible language and cognitive delay (Byrne, Ellsworth, Bowering & Vincer, 1993). However, it is worth noting that several of these studies emphasise the impact of environmental factors (Lee & Barratt, 1993), and social grouping (Smith, Ulvund & Lindemann, 1994) in influencing reported outcomes in these domains for these children.

With continuously evolving technological advances and improved neonatal care, the mechanisms by which very premature and very-low-birth-weight babies may be kept alive have improved significantly, giving rise to a number of important ethical questions. Accompanying the growing population of neonates surviving prematurity and/or other complications at birth comes a potentially growing population of children with specific needs. The interplay of factors surrounding this population places them at risk for certain neurodevelopmental and sensory disorders, amongst these permanent hearing impairment.

Using logistic regression techniques, Davis (1994) attempted to identify which specific factors may be relevant, in terms of increased risk for hearing impairment, for children coming from the NICU. The three main risk factors which his analyses identified as being significant were:

(i) birth asphyxia (anoxia), (ii) history of fits and (iii) ototoxic drugs (gentamycin).

The prevalence of congenital hearing disorder amongst those children from the NICU with none of the above risk factors was estimated to be 0.13%. This estimate rose to 1.4% with the presence of one risk factor, 1.7% with two risk factors and 8.8% when all three risk factors were present.

With all three risk factors, a child was 63.2 times more likely to have a hearing impairment than a child with no risk factors.

A further complicating factor in the NICU baby population is the high probability that the hearing impairment is accompanied by other symptoms of chromosomal abnormality, major congenital anomalies or other neurological problems. Davis & Wood found that 71% of the children in the cohort examined in their study had 'other problems'[1], while only 15% of the sensorineurally hearing-impaired children with other problems were non-NICU graduates. (A more recent study however provides a more conservative estimate of 40% - Fortnum et al., 1996). Thus the number of children from the NICU population who present with hearing impairment alone and no other problems remains quite small.

[As a result of this, it was recognised that a number of children who might be targeted as participants in this research may be NICU graduates, particularly those that may have been identified early. The prevalence of potential 'other problems' within this group poses somewhat of a dilemma, in that hearing-impaired children from this group may have developmental deficits that exist in isolation of that caused by their hearing impairments. Later sections detail how this potentially confounding variable was managed.]

1.1.4 Consequences of Hearing Impairment in Childhood

The discovery that a child has a hearing impairment, particularly for a family with limited knowledge about congenital hearing loss, can have a devastating impact. Preliminary research has shown that feelings of intense guilt, self-blame, grief and anxiety are often expressed primarily by parents, often giving way with time and knowledge to an informed acceptance of the impairment and its potential effects

[1] 'Other problems' – e.g. neurodevelopmental disorders linked to syndromes, morphological deformity and other sensory deficits.

(Marsharck, 1993). In some cases however, these feelings can persist and fail to resolve over time (Musselman and Kircaali-Iftar, 1996).

Childhood hearing impairment has a number of potential consequences, perhaps the most obvious being a degree of disruption to the 'normal' language acquisition process. It has the potential to become, but by token of its presence alone is not necessarily, a handicap or a disability (Bone and Meltzer, 1989)[1]. If a hearing-impaired child goes on to develop spoken language, there may be some delay or deviation from paths of language development observed in normal-hearing children. In some cases of profound hearing loss, it may be more viable for the child to learn a manual mode of communication (i.e. sign language). However, as the majority of hearing-impaired children are born into hearing families, sign language learning does not often exist as an early language acquisition option. This may place severely-profoundly hearing-impaired children, who may find it difficult to acquire spoken language, at particular disadvantage.

Recent evidence suggests that early acquisition of, and exposure to, sign language, for those children likely to have some difficulty developing spoken language, may be beneficial for long-term development in a variety of linguistic, emotional and cognitive domains. It has also been suggested that early and consistent use of manual communication, as in the case of deaf children with deaf parents, can lead to the development of *spoken* language skills at least as good as those found for deaf children with hearing parents (Geers and Shick, 1988). In addition, Newport (1990) provides evidence that early exposure to sign language may have important

[1] See Bone and Meltzer (1989) OPCS surveys of disability in Great Britain, Report 3: The prevalence of disability among children, for more detail.

implications for the acquisition of that language. She studied the production and comprehension of American Sign Language (ASL) in three groups of deaf adults who had either (1) been exposed to ASL from birth, (2) acquired ASL in early childhood (age 4 - 6 years), or (3) acquired ASL after the age of 12 years. All participants had 30 years or more experience with ASL and all were proficient adult signers. Newport found that native fluency in ASL had only been achieved by those individuals who had been exposed to ASL before age 6. While significant defects were observed in the third group's production of complex sentences and function morphemes in particular, even individuals in group (2) were observed to have subtle defects in their language abilities. This study suggests that, regardless of the modality of language to be acquired, early exposure to language has important implications for language acquisition and development.

Evidence from Peterson and Siegal (1995) demonstrated that profoundly hearing-impaired children (of hearing parents) who are not exposed early to proficient sign language, may have considerable problems with false belief tasks. They found that children in this category performed comparably to autistic children on these tests. Other populations have been found to have little problem succeeding on false belief tasks and the ability does not seem to be related to IQ. Children with Down's syndrome, with specific language disorders, emotional disturbance and children with lower IQ scores than the hearing-impaired group looked at were all able to perform the task accurately. The performance of the hearing-impaired children on false belief tasks was found to be comparable to that of autistic children, for whom a neurological impairment is thought to underpin the observed deficit. The investigators suggest that the lack of early conversational interaction about intangible thoughts and feelings may underpin the poor 'theory of mind' development seen in the hearing-impaired children. Interestingly, the performance of two profoundly deaf children, who had received early exposure to sign language, was found to be markedly better. In addition to highlighting the inter-relatedness of language and social development, the study indicates an area of potential disadvantage for profoundly hearing-impaired children who may be identified late, and thus exposed late, to an appropriate language medium (in this case sign language).

Language development and mode of communication thus constitute areas that are affected by the presence of a hearing impairment. There are of course others, including the child's social development and development of self-esteem (Batchava, 1994), communicative competence (Harris, 1992), educational development (de Villiers, 1992) and long-term opportunities for training and career development (Gregory, 1995). It is worth stressing that these areas are inter-dependent, as illustrated by the findings from Peterson and Siegel (1995). Downs (1994) also highlights the relationship between improved speech and language abilities and employment prospects for hearing-impaired individuals. Thus development and success in one area may inevitably impact on development in another. All these areas, and possibly others, may be adversely affected by the presence of a congenital hearing impairment. Many of these areas remain under-researched.

However, the potential negative consequences of congenital hearing impairment may be modified by several important factors – the degree and nature of the hearing loss and the absence of other disorders; the age of the child at the time of detection

(Strong, Clark & Walden 1994); the level, type and quality of intervention received for the hearing impairment (Musselman & Kircaali-Iftar, 1996) and the point at which such intervention is introduced (White & White, 1987). Family social status, hearing-status and attitude towards a child's hearing impairment may also play a significant role, as may parental input, educational provisions, and the level of additional support (counselling, advice) available.

The importance of such factors has been highlighted in longitudinal work conducted by White and White (1987), who investigated the effects of such variables as age of intervention and the hearing status of parents on expressive and receptive communication in hearing-impaired children aged 8 to 36 months. Using a modified version of the Revised REEL (Receptive and Expressive Emergent Language) Scale (Bzoch & League, 1971), they found a highly significant main effect ($p < .001$) of the age of intervention on language performance for hearing-impaired children. (Age of intervention was indicated by the age of detection and the age of hearing-aid usage). This effect was particularly consistent for children of hearing parents, and less so for those with deaf parents, particularly in advanced categories of receptive language assessment. However, when emergent speech and early expressive language were considered, the effects of early intervention appeared to be larger for the hearing-impaired children of deaf parents. For both groups of children, attainment of advanced categories of expressive behaviour were found to be low, with the children of hearing parents, detected late (after 18 months of age) performing poorest. The study highlights the potential impact of some of the variables listed earlier, as well as the importance of considering the interactive effects of independent variables (parental hearing status and age of intervention) on children's language attainment scores.

1.2 HEARING IMPAIRMENT AND LANGUAGE

1.2.1 AUDITORY DYSFUNCTION AND POTENTIAL EFFECTS ON LANGUAGE

The detrimental effects of hearing loss on language, speech and communication have been evoked many times by researchers (Levitt, McGarr and Geffner, 1987). Generally, early detection and intervention are considered essential to maximise a hearing-impaired child's chance of developing 'normal' spoken language so that the success of early intervention is widely measured in terms of the hearing-impaired child's acquisition of 'normal' spoken language. However, to measure language purely in terms of verbal communication is problematic as language involves the use of various modes of communication – gestural and non-verbal, as well as vocal.

It may also be problematic that, while normal language development serves as an indicator of the success of the management of hearing loss, for some hearing-impaired children poor language development can often precipitate the detection of hearing loss in the first place. This may be especially true in cases of mild or moderate hearing impairment, where detection often only occurs when language development is perceived as delayed, prompting parental and/or professional concern. Thus the language delay leads to the child's hearing being tested and to the hearing impairment being detected.

Some evidence that disentangling the relationship between language deficit, hearing loss and other interacting factors may be difficult is provided by Gilbertson & Kamhi (1995). They found that degree of hearing loss was *not* related to novel word learning abilities for a group of mild-to-moderate hearing-impaired children, and suggested that children with this range of hearing impairment may fall into one of two distinct groups – normally developing children who have a hearing impairment and language-impaired children who have a hearing impairment.

Despite the frequent reference made to the hearing-loss/language-delay relationship, excluding profound hearing impairment, the evidence relating them to one another convincingly for remaining categories of hearing impairment (mild, moderate, severe) is relatively sparse. The studies which do exist in this area, along with a review of research which has looked at language development in hearing-impaired children, are reviewed in more detail in Chapter Two.

1.2.2 ACQUIRED AND CONGENITAL HEARING LOSS

The different forms that childhood hearing impairment might take were outlined at the beginning of this chapter and the distinction was made between those hearing impairments that are congenital (where hearing-impairment is present at birth) and those that are acquired (where hearing is lost after birth).

Language acquisition in children with congenital hearing impairments often differs from language acquisition in children with acquired hearing impairments. A child with a congenital hearing impairment will have a diminished and/or disrupted experience of incoming auditory information. The degree of disruption will be affected by the nature and severity of the hearing impairment. Early auditory experience, essential for later spoken language development, will thus be reduced and/or distorted. As a result, children with more profound hearing impairments may often gravitate towards a different language medium and develop sign language. This does not mean that hearing-impaired children cannot or do not go on to develop proficient spoken language, particularly those children with mild-to-moderate hearing impairments. However, factors which may be of less importance for normal-hearing children may have a significant impact on the process of spoken language development for congenitally hearing-impaired children.

Children who acquire their hearing impairments later in childhood have, for the period up to the onset of the hearing loss, normal incoming auditory information. Even if this period is relatively short, the importance of exposure to the phonology of the language in their environment may serve an important perceptual-linguistic function. Research on categorical perception suggests that neonates are able to make language-specific phonemic distinctions from as early as two to four months of age (Oller, 1980), implying that some form of perceptual encoding may have taken place by then. Children who acquire their hearing impairments post-lingually, in late childhood, may often go on to continue to develop and use spoken language well, using visual cues (i.e. lip/speech reading) in combination with phonological memory. While the clarity of speech produced may show some disruption over time, language often remains intact in these circumstances. As such, it is reasonable to assume that children with post-lingually acquired hearing impairments have attained important linguistic building blocks which enable continued language development. An indicator of this is that cochlear implants have proven most successful for individuals who have acquired their hearing impairments post-lingually (Summerfield, 1995).

Comparable information about spoken language will be unavailable to children with profound congenital hearing impairments. Children with congenital or pre-lingual hearing impairments were the focus of the studies presented in this thesis.

1.2.3 Sensitive periods for language acquisition

A sensitive (or critical) period consists of a specific period of time during which an organism maximally responds, or shows heightened sensitivity, to aspects of the external environment in relation to some feature of its development. It has been defined by different experimenters in various ways, with the main emphasis being that external sensory stimuli have an important effect on the formulation of neural connections. Eggermont (1986) produced the following definition of 'critical period' from a combination of more restricted definitions:

> "a period during which the action of a specific stimulus is required for normal development of the system, and during which the organism is maximally vulnerable to environmental manipulation". (Eggermont, 1986)

Critical periods of this kind have been extensively researched and have been demonstrated to be a common feature of sensory mechanisms in a number of animals. In particular, studies on the visual system (Weisel & Hubel, 1963; Blakemore, 1978) have demonstrated how deprivation of specific stimuli can result in the retarded development or abolition of certain developmental features. More recently, similar but subtler (experience-sensitive) mechanisms have been demonstrated to exist for the auditory system (Rubel, 1985). However, it has remained difficult to extrapolate from animal studies, thus it has been more difficult to establish experience-sensitive periods of this kind for humans. Nevertheless, these findings have often been used to support the suggestion that there exists some similar restricted time-frame for elements of human development.

More recently it has been suggested that staggered development of different brain regions occurs, resulting in different sensitivities and maturational time courses for developmental features (Greenough, Black and Wallace, 1987). Various time frames have been posited in relation to speech and language acquisition processes. Some researchers have suggested that the first two years constitute the 'sensitive period' for language development. As such, it has been suggested that auditory deprivation within the first two years may impact most significantly on aspects of language and cognitive development (Webster, 1983). The NIH Consensus Statement (1993) proposes that the first three years are generally regarded as 'the most important period for language and speech development'. Others propose that developmental changes occurring between ages 2-to-4 years are of particular importance (Corballis, 1991), while some investigators propose periods of sensitivity which more closely parallel the protracted period of postnatal neural development observed from birth to puberty (Neville, 1991).

Certainly some behavioural evidence from cochlear implant studies suggests that a sensitive period for spoken language development may not be so narrowly defined, as some success is being demonstrated in spoken language perception and production with profoundly hearing-impaired individuals, born deaf, who receive implants in late childhood (Summerfield, 1995). In addition, while the development and progress of spoken language in children implanted at older ages might not be as swift as that observed in children implanted at younger ages (Tye-Murray, Spencer & Woodworth, 1995), results are still encouraging.

While it appears that information from the linguistic environment is an essential element for normal language acquisition to occur, and that our ability to acquire a first language diminishes with age, the length of the period of sensitivity, and whether or not it is the same for all individuals, is undetermined. The potential existence and length of such a period (or periods) obviously has important consequences when we consider first language acquisition for hearing-impaired children. The question of how such a sensitive period might vary depending on the modality of language development (i.e. spoken/signed/both) is also of importance, although a study conducted by Newport (1990) (cited earlier) suggests that early exposure to sign language (before age six) is essential if it is to develop proficiently. If narrowly defined as being confined to early childhood, as has been suggested, greater emphasis would need urgently to be placed on the very early detection and diagnosis of hearing impairment. The evidence however is far from consistent or conclusive.

The acquisition of sign language by deaf children, or by hearing children born to deaf parents, has shown itself to be similarly subject to experiential sensitivity. Neville (1991) provided evidence pertaining to the influence of early experience on language and cognitive processing. She showed that acquiring sign language early as a first language, for both deaf and hearing subjects born to deaf parents, resulted in left cerebral asymmetry for the detection of the direction of motion. This asymmetry was opposite to that found for hearing non-signers (where the right hemisphere mediated the detection of motion direction). Thus early language experience demonstrably influences cerebral development and specialisation.

The implications of a sensitive period for spoken language acquisition in aided hearing-impaired children lacks detailed evaluation. This information may be invaluable in determining the optimal period from which a child might benefit from aiding and intervention (or from implantation, should that be considered a viable option). More urgently, there is a need to assess the potential benefits and the time of maximum benefit for hearing-impaired children who wear conventional aids and who constitute the majority of hearing-impaired children. Particular emphasis may need to be placed on those children with mild-to-moderate hearing impairments for whom conventional aids are potentially of greatest benefit. Even for those with more severe hearing losses, the evaluation of the possible benefits of receiving hearing aids and/or early exposure to sign language is essential, especially when one considers that one of few alternatives, cochlear implants, are at present costly, potentially inappropriate, and largely unavailable for the majority of hearing-impaired children.

1.2.4 INTERVENTION FOR HEARING-IMPAIRED CHILDREN

The success of early intervention programmes (typically before age three) for deaf children, incorporating their families have been demonstrated (Greenberg and Calderon, 1984; Greenberg, Calderon and Kusché, 1984). Even so, little substantive outcome evaluation research has been conducted on these or on the benefits of very early intervention for hearing-impaired children and their families. It has been suggested that research in this area is hampered by small heterogeneous potential subject groups and the prevalence of additional handicaps which may impact on outcomes (Garwood, 1982).

According to Greenberg et al. (1984a), effective intervention for hearing-impaired children should begin immediately after diagnosis and contain four components: (i.) initial counselling for parents to deal with their anxiety, anger and fear, and to help them comprehend the diagnosis and develop realistic expectations for their child; (ii.) hearing aid provision; (iii.) facilitation of early communication and (iv.) continued counselling and communication training for the family (at least until child is school age). White and White (1987) on the other hand propose that the following three-pronged approach should underpin effective remediation programmes for hearing-impaired children: (a) the use of appropriate assessment instruments to measure progress; (b) the use of appropriate models to be able to understand and counteract failure, and (c) the ability to remain flexible, because this recognises that the deaf population is heterogeneous (p. 23).

It may be useful to make a distinction between first and second level interventions. For any child with a hearing impairment, first-level interventions may be described as those which focus on the hearing impairment itself (e.g. hearing assessment, hearing-aid provision). Second-level interventions may be described as those that focus on improving the child's/family's ability to manage the impairment (e.g. counselling, communication training).

Both first-level and second-level interventions for hearing impairment involve several stages, consisting of detecting the hearing impairment early (within the first year), prompt referral and accurate diagnosis, followed by providing the child with hearing aids, given that there are no complications such as middle ear disease. If a conductive overlay, or middle ear disorder, is found, referral for surgery (e.g. grommet insertion) may be recommended prior to hearing-aid fitting. These might all be categorised as first-level interventions. So far, these focus consistently on the actual impairment and on the child's needs. However, interventions should not end here or exclude parent/family-centred approaches. Although detection and aiding are crucial aspects of intervention, other variables have been identified as being important elements of good intervention. As well as prompt referral, diagnosis, and hearing-aid fitting, consistent wearing and use of hearing-aids needs to be encouraged by the child's family. Appropriate supplementary educational provisions need to be made available to children and their families, and the provision of training, counselling and advice for parents is imperative (Marlowe, 1993; Phillips & Cole, 1993). These might be categorised as second-level interventions. However, parental counselling, training and other second-level interventions need to be included throughout all stages of the management of childhood hearing impairment, and begin from the time the hearing impairment is initially suspected. In addition to interventions which are made available *after* the identification of hearing impairment, there may also be an important role for family-centred interventions which target 'at-risk' families. This may involve providing parents whose children are at-risk for hearing impairment (e.g. where there is a family history of hearing impairment) with information and counselling *before* the birth of their child, enabling them to be better prepared in the event that their child is found to have a hearing impairment.

1.3 CHAPTER SUMMARY

Profound congenital hearing impairment is estimated to affect around 1 in 3 – 4000 new-born infants annually, a figure which rises steeply (to around 1 in 1000) if we consider infants born with other degrees of hearing impairment (i.e. mild, moderate and severe). Without prompt identification and appropriate intervention, these children may be at particular disadvantage developmentally, in particular in relation to language, communication and cognitive skills. Although the average age of detection has been reduced for children with profound hearing impairments, this does not seem to have occurred for children with mild/moderate and severe hearing impairments. Questions pertaining to the benefits of early detection and intervention for children with mild-to-severe hearing impairments still remain to be addressed. These questions are of increasing importance as the numbers of children detected with hearing impairments in these categories may increase as the sensitivity of screening techniques improves.

Many factors combine to affect the development of hearing-impaired children. Factors which have been espoused as potential influences of developmental 'success' for hearing-impaired children include the degree and severity of the hearing-loss, psychological, psychosocial and environmental variables – including familial response, involvement and interaction (Musselman and Kircaali-Iftar, 1996), as well as how early the hearing loss is detected and when intervention begins (Strong, Clark & Walden, 1994). To date, although early intervention is presumed to be beneficial for all hearing-impaired children, few studies have evaluated these benefits, and little evidence exists relating to them. Neither has research produced definitive suggestions as to *when* it might be optimal to intervene. Research illuminating our understanding of issues of plasticity and 'sensitive periods' for development are inconclusive but form an important part of the discussion.

The research presented in later chapters attempts to fill some of the gaps in the literature, particularly those relating to the impact of age of intervention on specific outcomes for hearing-impaired children. The effects of hearing-loss severity and factors relating to intervention were evaluated, with particular focus on children with mild-to-severe hearing impairments.

One of the most thoroughly documented outcome variables in the field of child-development research is language. A number of factors make it probable that the majority of hearing-impaired children will attempt to develop spoken rather than sign language. Two factors are that:

(i) the vast majority of hearing-impaired children are born to hearing parents and

(ii) prompt amplification may enable available residual hearing to be utilised well.

These factors mean that most hearing-impaired children initially acquire and communicate via spoken language. Therefore, spoken language and communication were chosen as tools with which to attempt to evaluate the benefits of a range of factors, including early intervention, for these children.

Chapter Two reviews the literature concerning the development of language and communication in normal-hearing and hearing-impaired children.

CHAPTER TWO

CHAPTER TWO

2.1 DEVELOPMENT OF LANGUAGE

2.1.1 NORMAL LANGUAGE DEVELOPMENT: AN OVERVIEW

The specific mechanisms underpinning child language acquisition and development have been subject to a wealth of research and debate. Child language acquisition has been described as a process which maps a series of well-defined, but over-lapping stages which typically occur between birth and 6 years of age. The stages in language production include cooing and babbling – moving from canonical (Oller, 1980) through to variegated (Stark, 1980) babbling, e.g. /bababa/. First referential word emergence has been shown to often occur at around 9 to 12 months of age, followed by a slow but steady vocabulary growth over the next 6 to 8 months. It has been observed that when a child's vocabulary consists of 50 or so words, a naming explosion or rapid increase in vocabulary typically occurs, usually between the ages of 2 and 6 years. During this period, children have been reported to acquire something of the order of nine new words per day, although vocabulary growth continues at a high rate through adolescence (Pinker, 1994). The formation of two-word utterances is typically observed when children are around 18 to 24 months of age. By the end of the second to mid third year, children are combining words to produce longer and more complex sentence structures (Brown, 1973).

These milestones do not represent finite and distinct units of language development and often overlap. Individual differences also exist and normal children can be found to differ by at least a year in their rate of language acquisition (Pinker, 1984). Despite this children generally show little variance in their patterns of syntax acquisition (Brown, 1973; Stromswold, 1990), even though the time course may be extended. Therefore language milestones are typically used as indicators that language development is progressing normally.

In addition, children have been reported to produce few errors and linguistic confusions, for instance between auxiliary and functional verbs. Errors which do occur are reported to do so with a high degree of consistency between children. The over-regularisation of inflectional endings such as *-ed* for past tense and *-s* for plurality in English are examples of this (although Pinker (1995) suggests that over-regularisation may be adequately accounted for by a limitation in memory retrieval for children at the age when these errors are often produced). It has been shown that infants have the ability to preferentially process specific classes of input and selectively attend to relevant input properties (Karmiloff-Smith, 1993). For example, using behavioural adaptation procedures such as the amplitude of sucking technique, infants seem to preferentially attend to speech sounds and perform consonant discriminations (Bishop, 1993). These common indicators observed in the course of child language development, amongst others, have been posited in support of the existence of an innate language-specific mechanism which underpins and directs the child's acquisition of language (Chomsky, 1988; Crain, 1992; Pinker, 1994). However, the conceptualisation of language acquisition as a process which maps a series of well-defined stages has been challenged and criticised as an oversimplified framework within which to consider language development (Mitchell & Kent, 1990).

More recent and ongoing work in the area of cognitive neuroscience has produced data establishing the existence of speech and language specific representational systems in left hemispheric regions at birth (Mehler & Christophe, 1995). This further evidences the existence of 'innately-constrained, domain specific attention biases or predispositions' for language (Karmiloff-Smith, 1993, p. 564).

The more comprehensive accounts of language development (and human development generally) invoke both innately-specified predispositions and experience of environmental stimuli in explaining how development successfully occurs. These accounts recognise the complexities of possible interactions between an innate mechanism, which may act to constrain environmental input, and factors related to the flexibility and plasticity of developmental processes. As such the language acquisition process is known to be dynamic and complex.

A detailed consideration of the numerous and various research findings and theories relating to child language acquisition is beyond the scope of this thesis. There are numerous publications which review this area in detail – some recommendations are Atkinson, 1982; Ingram, 1989, 1994; MacWhinney, 1987.

Of relevance to this research is a consideration of what might happen to 'normal' patterns of language acquisition in circumstances where the processing of auditory information is impaired, as well as how any interaction between innate language-specific mechanisms, the environment and individual differences may be affected in these circumstances.

2.1.2 IMPLICATIONS OF NEURAL PLASTICITY FOR AUDITORY AND LANGUAGE DEVELOPMENT

Lenneberg (1967) proposed that the acquisition of language is governed by a critical period which relates to the maturation of other developmental systems (see Chapter One). Coupled with the probable existence of critical, or sensitive periods, for aspects of development, is the concept of plasticity. For individuals with hearing impairment, issues relating to the development and plasticity of the auditory system and how this might impact on experiential sensitivities for language acquisition are of relevance. Some of these issues are briefly reviewed below.

The auditory system is centrally synthesised, that is projectional maps based on neural processing exist whereby the external receptor surface is topographically represented by structures of the central nervous system. Both normal developmental, and abnormal sensory, experiences can result in changes to both types of map (the external surface map and the neural map) (Rubsamen 1992; King and Moore, 1991). These sorts of changes within the auditory system are what are commonly referred to as 'plasticity'. Tsukuhara (1981) provides a general definition of plasticity as:

"*any persistent change in the functional properties of single neurons or neuronal aggregates*" (cited by Irvine & Rajan, 1995, p. 351).

Black (1995) however provides a more flexible and broader definition in proposing that plasticity:

"*refers to brain mutability and flexibility, which underlies alteration of structure and function over time in response to environmental change.*" (Black, 1995, p.5).

Black further specifies that this plasticity rests on molecular and cellular determinants which in turn fundamentally underpin *all* aspects of cognitive development.

Neural plasticity is not restricted to early development and is a feature that can be observed in adult animals. As such, a large body of the experimental work on neural plasticity has been conducted on adult animals and some findings from this work are reviewed here before its implications for developmental plasticity (observations of plasticity during early development) are considered.

Representational maps in adult animals, once thought to be subject to little change, have been found to alter in the event of changes in sensory input. Recent evidence has shown that this occurs for a variety of species and that changes in sensory input can result in map reorganisation in the somatosensory cortex. Visual cortex reorganisation after retinal lesions, for instance, are well-documented (Kaas, 1991) and adult auditory cortex reorganisation following cochlear lesions have been demonstrated (Rajan, Irvine, Wise & Heil, 1993). This evidence would suggest that varying levels of neuronal plasticity are a regular feature of sensory cortices at various stages of development and life (Irvine & Rajan, 1995).

Auditory deprivation in humans has been shown to result in the reorganisation of structures within the visual system, particularly those involved in the processing of peripheral visual information (Neville, 1991). Experimental work conducted to investigate such reorganisation primarily utilises animal models. Using experimental techniques, the removal of sensory stimulation has been shown to directly lead to neuronal changes. For instance, restricted cochlear lesions produce immediate changes in the auditory nerve fibre response, and the responses of central auditory neurons corresponding to the damaged region of the cochlea are affected. Irvine and Rajan (1995) argue that, strictly speaking, these types of changes cannot be generally considered examples of plasticity as defined by Tsukahara (above). They broaden the definition of plasticity to refer to 'changes in the functional properties of neurons that depend on changes in connections or in synaptic strengths' and from this basis provide a comprehensive review of plasticity in the adult auditory system. In their work they focus on frequency tuning and cortical and subcortical organisation in non-human animals.

In some earlier studies, Robertson and Irvine (1989) found that unilateral cochlear lesions in the guinea pig resulted in enlarged representations of limited frequency regions. Normally, an orderly and continuous representation of frequencies (10–20 KHz) would be found. These forms of reorganisation following sensory deprivation parallel those observed in the somatosensory and visual cortices. Irvine & Rajan (1995) proposed that reorganised frequency representations in chronically lesioned guinea pigs are indicative of neural plasticity because (1) strong neural responses are exhibited in the reorganised regions of the cortex with new central frequencies (CFs) similar to those of CFs in normal animals; (2) these cortical changes (along with elevated thresholds) are not observed a few hours after lesion, but after a period (a month or more) of abnormal sensory input. What are known as pre-lesion 'residue' responses are recorded immediately post-lesion and real changes in reorganisation are therefore not observed until later. This contrasts with findings from studies of somatosensory and visual cortical plasticity, where immediate changes in neural responses are observed. The difference in changes over time, Robertson & Irvine suggest, establishes that there is a dynamic process of reorganisation during the recovery period. Further experiments investigating the effects of unilateral cochlear lesions in adult cats confirm that plasticity (true reorganisation of frequency representations) rather than pre-lesion residual responses were being observed.

Further evidence of the dynamic reorganisation of frequency representation following cochlear lesions was provided by Schwaber, Garraghty & Kaas (1993). In this study, high frequency induced hearing loss in macaques was similarly found to result in enlarged cortical representation for frequencies on the edge of the lesion. However, unlike Robertson & Irvine the authors do not disambiguate between true frequency reorganisation and potential pre-lesion residual responses. Nevertheless, the examination of frequency representation in animals with naturally occurring peripheral hearing losses have provided consolidatory findings (Willott, Aitken & McFadden, 1993). Generalising from these studies, it seems probable that auditory dysfunction in humans may result in similar patterns of frequency reorganisation.

To summarise, the precise loci of changes which result in observed reorganisation remain unclear, but it would seem that mechanical lesions result in dynamic frequency reorganisation within the auditory cortex of adult animals. However, reorganisation of the auditory cortex following neonatal lesions produces a developmental plasticity which differs from the plasticity found in studies on adult animals. It has been proposed that developmental plasticity may involve other neuronal mechanisms. Developmental plasticity is considered below.

It has been found that during fetal development factors affecting auditory system functioning relate to cochlear development and innervation. After (full-term) birth observed developmental changes involve auditory nerve myelination, changes in the brain stem tracts and inter-cellular connections in the cortex (Eggermont, 1989). While reorganisation following peripheral damage to the adult auditory system demonstrates that cortical and subcortical sensory structures have the capacity to modify if altered sensory input is received, the benefits of the reorganisation are difficult to surmise – it seems to afford no compensatory function. Existing anatomical constraints however make it unlikely that the mechanisms that account for neonatal auditory system plasticity also account for adult auditory system plasticity. It seems probable that peripheral damage to the neonatal auditory system may be quite different in that reorganisational changes may afford some compensatory function in these situations. An example might be in the event of early cochlear implantation. Differences observed between children and adults in recovery from various forms of acquired brain damage lends some support to this theory (Lenneberg, 1967).

Evidence has also been derived from studies on learning-induced plasticity. As the term implies, learning-induced plasticity makes use of learnt behavioural responses to investigate plasticity in developing and adult animals. If taught to make specific responses to particular stimuli, the influence of subsequent neuronal changes can be investigated via changes which might ensue in the animal's responses.

Learning-induced plasticity has been demonstrated in adult animals trained to make subtle frequency discriminations over a number of weeks (Reconzole, 1993). These behavioural changes have been found to be stimulus-specific and to correspond to neuronal changes in the form of increased areas of frequency representation. Other studies have demonstrated that training – conditioning with specific stimuli – can lead to changes in the frequency selectivity of cortical neuron clusters (Weinberger, 1993), and that these changes can be permanent.

The specific mechanisms involved in auditory plasticity have not been identified. In addition, whether or not the same mechanisms underpin these differently induced examples of plasticity is unclear. It has been suggested that the mechanisms may be intrinsic to the neocortex, are self-organising, and are responsible for the refinement of cortical maps related to higher order cognitive processes (learning, memory) during development. Cortical plasticity has been invoked to explain data on frequency discrimination and visual perceptual learning, but there may also be plasticity at subcortical levels. Alternatively, it has been suggested that neuronal groups and synaptic connections corresponding to previously dominant inputs (which have now been eliminated by peripheral lesion) result in inputs that were previously expressed weakly, if at all, becoming more effective. This implies that alterations in input influence the stabilisation of certain connections and the elimination of others.

Ryals, Rubel & Lippe (1991) discuss the implications of neural plasticity for cochlear implantation in children. They suggest that developmental changes affect tonotopic neuronal organisation in the auditory pathway, leading to a progressive apical shift along the cochlear partition and central auditory pathway. As a consequence, frequency organisation is not fixed but dynamic during development.

Neurons along the central auditory pathway change characteristic frequency (CF) during development, and it has been postulated that parallel anatomical changes occur. This developmental feature of the auditory system was first referred to as the 'shifting-place' principle (Rubel, Lippe & Ryals, 1984).

The fact that the development of hearing begins with low to mid range frequency discrimination is well documented (Rubel, 1978; Lippe & Rubel, 1983). High frequency discrimination is not demonstrable until later in development. Rubel (1978) showed that behavioural and electrophysiological responses to low frequency sound could be elicited before responses to higher frequency sounds (~3 KHz) in fetuses 24 to 30 weeks gestation. These observations are paralleled by anatomical data. As a result of the findings in behavioural and electrophysiological responses, it might be anticipated that the apical turn of the cochlea should mature first, i.e. that part of the cochlea corresponding to low frequency sounds. However the organ of Corti develops from the base to the apex, thus the base (which corresponds to high frequency sound) develops first. The base thus responds to low frequency sound during the earliest periods of development, gradually shifting as the rest of the cochlea develops to respond to high frequency sound.

Early sensory stimulation is imperative for normal physiological, neural and perceptual development and it has been found that fetal environments are typically rich in low frequency sound (from ~ 24 weeks gestation) (Hepper & Shahidullah, 1994). This low frequency sound provides stimulation to all tonotopic regions in the central auditory nuclei. These observations would suggest that low frequency stimulation is of importance during the earliest stages of development. The question then arises as to how important low frequency input might be in the presence of neonatal hearing impairment. It may be that low frequency stimulation is essential for higher frequency neurons to mature.

One implication is that the same sound may be perceived differently at different stages of development. This possibility is supported by Hyson & Rudy (1987) who demonstrated that the auditory perception of rats changes during ontogenesis. Rats conditioned to respond to a specific low frequency tone would, 72 hours later, behave in such a way as to suggest that a higher frequency tone now corresponded to the earlier percept of a low frequency tone. In explanation, they proposed that the basal end of the cochlea is the first to mature and as such, early in its development, responds only to low frequencies. As the cochlea develops and matures, low frequency resolution moves progressively closer to the apex while the base responds maximally to high frequencies. They proposed that this shift in frequency-encoding along the basilar membrane will be mirrored by corresponding changes in central auditory system tonotopic organisation. The implication of this is that, if recordings are made from the same neuron throughout development, the characteristic frequency to which that neuron maximally responds should increase with maturation.

These findings have implications for the way in which early auditory stimulation may affect neuronal development in the auditory system. In turn, there are implications for the way in which the development of processes such as speech, which rely on the accurate encoding and repetition of direct and incidental auditory information, are affected and for the way in which early cochlear implants are assessed and evaluated in children.

Kuhl, Williams, Lacerda, et al. (1992) suggest that speech stimuli may be represented in the form of 'perceptual maps' by infants as young as 6 months of age and that these maps form a basis for the later development of spoken language. However they fail to discuss how these maps may be established in the first place or how they may be represented neurally. Others have specified that delays in the maturation of cortical areas concerned with the acoustic analysis of speech might in turn result in the impaired development of environmentally dependent mechanisms of auditory processing (Kurtzberg, Hilpert, Kreutzer et al., 1984) thus emphasising the interdependence of developmental processes.

In summary, it is known that the human brain has a protracted postnatal period of development and maturation, extending from birth to at least puberty (Neville, 1991). Evidence suggests that plasticity is a characteristic of the human brain that exists to some degree throughout adulthood as well as during early development. The precise nature and time frame of such plasticity has implications for the inter-dependent development of auditory perception, speech and spoken language. That is, evidence would seem to suggest that a deficit in the stimulation of one of these areas will impact on the development of another, and that this pattern of interference is reciprocal. This inter-dependence needs to be taken into consideration in determining how best to support and aid the (spoken) language acquisition process for hearing-impaired individuals. What seems clear is that individual differences, experiential and environmental factors are elements which must impact on any observed developmental plasticity to some degree (Kolb, 1989). The role of some of these factors are considered in the next section under the collective heading of 'environmental factors'.

2.1.3 LINGUISTIC ENVIRONMENT AND INTERACTION

"Especially in its early phases, and to a great extent throughout the life course, human development takes place through processes of progressively more complex reciprocal interaction between an active, evolving biopsychological human organism and the persons, objects, and symbols in its immediate environment. To be effective, the interaction must occur on a fairly regular basis over extended periods of time...Examples of [such interaction] are found in parent-child and child-child activities..." (Bronfenbrenner & Ceci, 1994, p.572)

Social interaction begins from the earliest stages of development and the precise nature of its role in the development of language and communication has proved difficult to quantify. What is certain is that exposure to the language of the environment and a degree of interaction with experienced language users within that environment seem to be imperative for normal language development to occur (Bruner, 1975; Curtiss, 1977).

Active participation in interaction and problem solving with a competent partner facilitates learning, not just in relation to language and communication, but also in relation to other higher mental functions (Vygotsky, 1978). Bronfenbrenner & Ceci (1994) formally emphasise the importance of environmental factors by mathematical modelling the interaction between innate language-specific mechanisms and environmental input. 'Proximal processes', the mechanisms by which social, environmental and biological factors interact, are considered pivotal in maximising the child's potential to develop. Central to their thesis is a reliance on a conceptualisation of learning earlier postulated by Vygotsky in his discussion of the zone of proximal, or potential, development (Vygotsky, 1978). Through it, he emphasised the facilitatory role played by adult partners in guiding children's cognitive development through increasingly more complex activities and levels of understanding. It was hypothesised that this framework of support encourages the child to extend his/her skill competence.

The sensitivity of young infants to features of their immediate linguistic environments have been well demonstrated. Cross-culturally, by about 12 months, infants are observed to respond appropriately to different prosodic patterns produced by speakers in vocalisations directed to them. Evidence suggests that they are able to perceive stressed syllables more easily than unstressed syllables, and in turn often produce the stressed syllabic portion of a word prior to producing the whole word (Gleitman & Wanner, 1982). In a similar way, the differential stress pattern found at the beginning of sentences has been put forward in explanation of how children may acquire auxiliary verbs from adult interrogatives (yes-no questions). Qualitative differences in intonation patterns corresponding to the language spoken at home have been observed in early pre-speech infant vocalisations (Levitt & Utman, 1992). However, attempts to quantify differences in the vocalisations using speech analysis have proved unsuccessful (Thevenin, Eilers, Oller & Lavoir, 1985). There is also evidence to suggest that the prosodic speech patterns of a particular language and speaker may be perceived by fetuses in utero (Lecanuet & Granier-Deferre, 1993; Shahidullah & Hepper 1994), and that infants between six and nine months show preferences for prosody specific to their native language.

Findings from the McGurk effect demonstrate that speech perception is not purely an auditory process and that it is strongly influenced by the visual percept of a speaker. McGurk & MacDonald (1976) first demonstrated how important visual cues gained from lip-reading are when speech is being processed. The auditory-visual illusions that are created for listeners when presented with incongruent auditory and visual information have been widely replicated (Green et al., 1991). Young infants in particular appear to make use of this polymodal information when representing speech, thus the reception of visual as well as auditory information is important. Speech representations incorporating both kinds of information could mean that, in light of reduced auditory input, one type of representation may become of increased importance for speech processing and language comprehension. Some evidence suggests that a subset of 'language impaired' children may have problems interpreting the non-verbal information that accompanies speech and is inherent in facial expressions (Nowicki & Duke, 1992). This failing may lead to these children being misdiagnosed as having specific language impairments (SLI) – language problems which cannot simply be related to intellectual or sensory deficits (Bishop, 1996). However, little work has been done on this phenomenon. These findings may have important implications for young hearing-impaired infants' early reception and development of language. An inability to interpret non-verbal information in facial expressions would leave them with a further disadvantage for comprehending spoken language as they make particular use of such information to determine the meaning of an utterance. And facial expression arguably plays an important role in sign language systems.

2.1.4 NON-VERBAL COMMUNICATION

Language can take several forms and is not just restricted to the verbal dimension. Non-verbal language was once thought to be a subsidiary system of communication, preceding verbal communication and serving little useful function once verbal language had been mastered (Weiner, Shilkret and Devoe, 1980). It is now widely recognised that communication incorporates many different modes – verbal, paralinguistic, gestural, non-verbal – all of which play important roles in communicative competence. Goldin-Meadow, Wein and Chang (1992) demonstrated that during conversations involving reasoning, children convey vital information through the use of hand gestures, information which they often omit verbally and which enhance the clarity of the message being given. Non-verbal imitation of adults and non-verbal participation in games provides essential information via which young infants are able to make sense of the linguistic code operating around them (Bruner, 1983), contextualise information, engage in joint attention to an object, and move towards the verbal labelling of objects. Eckerman and Didow (1996) suggest that it is through non-verbal imitative acts that toddlers create understandings of their interactional activities with a partner. The non-verbal acts facilitate comprehension of, and later response to, verbal utterances.

The language of a child's environment is therefore made up of verbal and non-verbal communicative information. There is evidence to suggest that hearing-impaired children make particular use of gaze and gesture within non-verbal communication strategies, and that these enable them to communicate as much as their hearing peers (Christensen, 1988).

Hearing-impaired children born into hearing families are deprived of the acoustic stimuli from their surroundings to varying degrees depending on the severity of their hearing impairments. However they do have access to the non-verbal gestures and signals which form an inherent part of communication and can be perceived as well as they can be by normal-hearing peers. De Villiers, Bibeau, Ramos & Gatty (1993) found that deaf mothers appeared to make far more creative use of gestures than hearing mothers to accompany speech directed to their hearing-impaired children. This resulted in the formulation of rich and varied gesture inventories which facilitated communication between parent and child, and may be an essential source of information in these particular circumstances.

2.1.5 CHILD-DIRECTED LANGUAGE: GENERAL FINDINGS

It is now taken as axiomatic that children are to some degree innately equipped to acquire language. What is more debatable is the suggestion that *adults* may possess universal adaptive traits enabling them to modify their language when speaking to children, thereby providing 'miniature lessons' about syntactic structure and turn-taking (Messer, 1995), phrase boundaries, prosody and semantics (Fernald, 1991). As well as evidence that speech may have been adapted to the auditory capacities of infants (Kuhl, 1981), cross-cultural similarities in child-directed language (CDL) or adult–child (A–C) speech have been reported (Papousek, Papousek & Haekel, 1987). However, several researchers have questioned these findings and warned against drawing inferences from these observations to formulate potentially erroneous theories about the function of CDL in child language acquisition (Richards, 1994; Pinker, 1995).

Amongst the work relating to this topic are suggestions that these speech modifications may function to create bonds between the adult and child and signal praise, comfort and disapproval. Characteristics of this supportive language include slow high-pitched speech, elaborate intonation contours and exaggerated prosody (Snow, 1973). Simplicity has also often been described as a characteristic of CDL, although the high proportion of questions typically found in CDL would suggest that this suggestion is misleading. It has been observed to be used by both males and females and has been reported to be non-culture specific, although this latter claim has been questioned (Leiven, 1994).

Experimentally, using behavioural dishabituation paradigms, infants appear to show marked preference for A-C speech over Adult-Adult (A-A) speech and there are numerous reviews on the possible facilitatory role of A-C speech in early child language development (e.g. Fernald & Kuhl, 1987; Fernald, 1991). However, the precise ways in which speech modifications like these might be supporting language acquisition are debatable. Similarly, it is unclear what elements of adult speech children may be using in their formulation of syntactic rules (supporting a distinction between input and intake), or what aspects of A-C speech/CDL may be important for atypical language groups. In all probability children's utilisation of adult speech may change with changing developmental needs. As such, the frequent representation of such processes as operating independently of contexts and of changes in children's needs may be questionable. Findings on this topic have been criticised for being inconsistent and open to various interpretations and post-hoc rationalisations (Scarborough and Wycoff, 1986).

The child, as an active participant in the process of language development, selectively exploits syntactic structures provided in surrounding linguistic 'models' for developmental purposes. Support for this perspective is evidenced by research findings which suggest that neonates appear to selectively attend to specific elements of environmental input. For instance they show preference for salient and useful linguistic stimuli above non-linguistic stimuli, utterances containing pauses at natural clause boundaries are preferred to those that do not, and disapproval is differentiated from approval in the intonation of an adults voice (Papousek, Bornstein, Nuzzo et al., 1990). This suggests that they are intuitively receptive to speech input and use it in their construction of linguistic rules.

Beyond the phonemic level, and in terms of the development of syntax, it has been found that certain elements of the language children perceive have little direct impact on the language they produce, thus suggesting that the relationship between linguistic experience and language development is a non-linear and complex one. For instance, consistent negative evidence – information about which utterances in the language are ungrammatical – rarely occurs in the feedback children receive from adult speakers (parents etc.). When it does, it is difficult to determine what information infants are using in their construction of grammatical theories (Pinker, 1984). Studies suggest that corrections, when they occur, tend to go unheeded by young children and there is no correlation between parental disapproval and instances of children's grammatical mistakes (Brown & Hanlon, 1970). Investigations into the function of positive evidence (tokens indicative of grammatical structure) have similarly yielded inconclusive results (Brown & Hanlon, 1970). Observations suggest that most of the time parents unconsciously provide a sound grammatical model for children acquiring language by token of their own utterances, but exactly how input may function to facilitate language development, to eradicate linguistic error and to highlight grammaticality is still undetailed.

Parents appear to respond to their children regardless of the grammaticality of the utterances produced. The fact that the child is merely speaking seems to motivate parental response, and the semantic content of child utterances appears to be more important to the parent than grammaticality. In addition, despite a wide range of input quality, normal children go on to develop functional language.

Generally, it would appear that minimal exposure to language and speech is sufficient for early language acquisition to occur. In circumstances where young children are regularly exposed to little or no regular direct linguistic input, as may be the case for the hearing children of deaf parents, oral language is observed to develop satisfactorily (Schiff-Myers, 1988), although a few instances of early atypical language development in these cases have been reported (Bishop & Mogford, 1988). Where some investigators have found that restricted language environments have resulted in language delays in children, their criterias for delay have been questioned (Messer, 1995). It is also possible that other factors, such as the presence of a specific developmental disorder or low cognitive ability, may have impacted on findings derived from case-studies of children reared in situations of extreme neglect and deprivation (Curtiss, 1977; 1989).

The role of child-directed-language for hearing-impaired children is considered in the following section.

2.2 LANGUAGE DEVELOPMENT IN HEARING-IMPAIRED CHILDREN

2.2.1 CHILD-DIRECTED LANGUAGE AND HEARING-IMPAIRED CHILDREN

For hearing-impaired children, a variety of factors may impact on the language they experience in their environments. These factors may influence different aspects of child-directed language and communication which may be important for shaping communicative and interactive behaviour. For instance, Mogford and Gregory (1982) found that parents respond in a different way to the vocalisations of deaf infants, tending to ignore them, while responding to the vocalisations of hearing infants. Even in instances where the very early canonical babbling of deaf infants was found to resemble that of hearing infants, parents would respond differently to these vocalisations, implying that their style of communication was being influenced by their knowledge of the child's hearing status, rather than by their actual perception of the child's vocal productions.

While it is possible to infer from Mogford and Gregory's finding that delayed knowledge about a child's hearing-impairment may lead to 'better' parental responses, it is unlikely that delaying parents' awareness that their child is hearing-impaired can be ulimately advantageous. It is arguable that early detection of hearing-impairment may enable the child's parents to be appropriately advised and encouraged to play an active role in facilitating the development of communication (in whichever modality) and in tailoring input appropriately to the needs of their child.

Robinshaw (1995, 1996) examined the communicative and linguistic behaviour of a group of deaf[1] infants and found that an important factor relating to successful

[1] Terminology as used by author

language development appeared to be the contribution made by the principle care-givers to the social interaction of the child. She suggests that this is one important factor, along with early intervention, which may have resulted in the finding that the children's communicative and linguistic development was similar to that observed for matched hearing peers.

Robinshaw's conclusions are derived from the detailed longitudinal study of a small group of five selected deaf infants. All the infants had been identified and aided by 6 months of age and were recorded regularly, at 6-week intervals, over a 15 month period. Robinshaw suggests that early intervention may counteract some of the deleterious effects of profound congenital hearing loss and maximise the opportunity for deaf infants to develop symbolic language early (in spoken or sign language). However, from her analyses, it is difficult to disentangle the relative contributions of environmental factors (e.g. care-giver sensitivity, input/intake) on the one hand and factors related to audiological intervention (e.g. hearing aid provision/amplification) on the other, or to determine to what degree these may underpin the comparative success of outcomes for the deaf infants. Furthermore, it is highly possible that participating in the research will have to some extent heightened the sensitivity and awareness of the care-givers to their infants' needs. Regular visits by the author would have invariably contributed to care-givers' awareness of their communicative strategies and techniques. The inevitable opportunity to discuss their child's progress and their own needs may have acted as a contributory factor similar to regular counselling for the parents involved. It then becomes difficult to ascertain what level and frequency of habilitative support parents and hearing-impaired infants might ordinarily need in order to render similar results. Therefore, while providing some evidence for the importance of caregiver habilitation and guidance, extrapolating from these findings to determine what degree of parental support would result in improved outcomes for deaf children remains difficult.

As with many studies focusing on early vocal behaviour in deaf children, it would also be interesting to determine whether observed patterns of delay increase as the infants acquire more complex forms of language. There is some suggestion that complex structures become difficult to acquire for hearing-impaired children as a result of insufficient and/or inferior input/intake. Alternatively, it has been suggested that it is only at later stages of language production that deficiencies in the early language that hearing-impaired children have received become apparent (Gregory, 1983). However, Gallaway and Woll (1994) have overviewed the difficulties in generally attributing facilitatory (and unfacilitatory) qualities to certain methods and styles of language/communication directed to hearing-impaired children.

Some research refers to the role of environmental language on the individual's development of language and communication in terms of language directed to the child (input) (Furrow, Nelson & Benedict, 1979), while others emphasise that children are active participants in communication, selectively using information derived from interactions, and that, separately to input, the nature of 'intake' should be considered (Gallaway, 1992). While it is generally accepted that language input and intake influence elements of, certainly early, language acquisition, the process is recognised to be multifaceted and complex. Conflicting findings relating to the relationships between the language perceived by children and the language produced by them are in part reflective of problems in methodology, definitions and interpretations. Furthermore, the fact that theories are often derived from small case studies and conducted in a narrow range of contexts makes reliability questionable and generalisation difficult.

Several studies, for instance, have characterised the language of hearing mothers to hearing-impaired children as being overly directive, antagonistic, controlling, rigid, and lacking in praise. It has been suggested that these characteristics are enduring and are generally unfacilitatory (Gregory, Mogford & Bishop, 1976).

General interpretations suggesting that some strategies are facilitative whereas others are not have been criticised as being unhelpful and unreliable. Individual differences are often neglected and the possibility that some of these strategies may actually be appropriate in certain contexts (e.g. with atypically developing children) is overlooked. It is often ignored that a clear understanding of the role of child-directed language in situations of typical development has not yet been established (Gallaway and Woll, 1994).

While a number of studies have considered the role of CDL for hearing-impaired children, several of these studies have failed to fully explore the potential impact of factors such as hearing level, age of detection, hearing aid usage, and parental attitude towards, and experience of, hearing impairment – all of which may influence interpretations. Furthermore, it is difficult to determine causality from the range of studies and findings presented. There is evidence that suggests that the language directed to a child is most affected by the speaker's perception of the child, as indicated by the findings from Mogford and Gregory (1982) outlined earlier. This perception may itself impact indirectly on the child's language development, through the way in which social interactions are established and maintained for instance. As such, it is not easy to disentangle the relationship between the language directed to a child and the child's use of language.

Seewald and Brackett (1984) demonstrated that a six year old child modified her language when speaking to a hearing-impaired child of similar age. The language modification employed by the child contrasted with the language she would use during interactions with a normal-hearing peer, an adult or a younger child. Although specifications regarding the hearing-impaired peer's hearing status (degree of loss, type of loss etc.) were not detailed in their study, the findings indicate that, even by the age of six, a speaker may modify her language in accordance with the perceived competence level of her listener. The shortest mean length of utterance was calculated for the child when speaking to her hearing-impaired peer, and the language she used was characterised by frequent use of the present tense, a high proportion of repetition and an 'instruction-oriented' tone. These elements contrasted with language used when speaking to her other interlocutors, although some modifications made when speaking to the young child were similar. Although the findings of this study would suggest that the speaker is influenced by the competence level of her listener, it is difficult to conclude that it is actually competence level that she is responding to. Her language modifications may alternatively have been influenced by her own assumptions about the deaf child's language ability or by some other less obvious characteristic of the deaf child or of the interaction scenario.

Nevertheless, adults have similarly been observed to modify their spoken language in relation to the perceived competence of their listener. The language of a parent to a young child is found to differ from that to an older child (and from that to an adult) (Rescorla 1989). Hughes (1983) found some similarity in the language/communication repertoires employed by parents of deaf children and parents of hearing children with comparable receptive language skills. Hughes found that, in comparison to Gregory and Mogford's observations, the hearing status of the child did not appear to significantly impact on conversation strategies. Gallaway, Hostler and Reeves (1990) conducted a study looking at quantitative and syntactic elements of maternal speech to hearing-impaired children. Their study, which included 74 children, took into consideration factors relating to the children's hearing impairments, such as hearing level. They found that maternal speech was most significantly influenced by the child's language level while hearing level did not appear to be a significant factor.

Further evidence suggests that language modifications are influenced by a different variable when the language involved is sign language. Musselman and Churchill (1991) found that hearing-mothers who communicated verbally with their hearing-impaired children tended to adapt their style to the spoken language ability of the child, while mothers who employed sign along with spoken language (i.e. total communication) would more frequently adapt their style to the child's level of social development.

From a different perspective, Black & Logan (1995) conducted a study focusing on turntaking skills and utterance types in parent-child communication. They found that poor communication, typified by irrelevant and inappropriate turn-taking behaviour and noncontingent and nondirected utterances, was related to the child's interaction skills with parents and peers, which were in turn related to the child's social status or popularity. Although the direction of causality is difficult to surmise, their study highlights how parent-child communication may influence child communication outside of the family domain while impacting on elements of social development. It also draws attention to the potential importance of recognising the interactive influence of factors under consideration.

A limitation of many studies investigating adult-child interaction and communication lies in the fact that young children are usually observed specifically in parent-child dyads. The generalisability of observations to other interaction contexts is therefore questionable. It is important to note that parent-child communication scenarios appear to be culturally specific, being more prominent in elements of western culture and less so in other cultural contexts. Dyadic interaction and direct parental guidance during joint cognitive activities may not be a common occurrence in non-western cultural communities. In alternative cultural settings children may communicate predominantly in larger group scenarios, with other family members (other than mother/father), or with other children in play situations, rather than in the traditional parent-child dyad (Super, 1981). Children in these circumstances do not appear to be disadvantaged or to suffer any detriment in their communication abilities or language acquisition skills. Therefore the emphasis that is placed on the parent-child dyad as serving an important facilitatory role in child language development may not necessarily be appropriate.

However, it may be that in specific circumstances the nature of linguistic input offered within the parent-child interaction dyad *is* more appropriate and perhaps beneficial, such as when we consider the needs of hearing-impaired children. In these instances, the opportunity to focus communicative attention on one other individual may be of great importance, providing a more coherent and easy to follow triangle of shared reference. The individual attention afforded to hearing-impaired children in these situations may enable and enhance the development of aspects of communication such as turn-taking, and may also ensure contingency in the information perceived by these children. Such a well defined communication context may hold advantages for maximising the hearing-impaired child's opportunity to develop linguistic skills (Wood, Wood, Griffiths & Howarth, 1986).

Linked into this is the importance of the cultural context itself in any analysis of language and cognitive development in general. There are cultural processes and variables beyond the immediate environmental/social factors which impact on development and later developmental outcomes (Gauvain, 1995). In particular, in order for children to become competent members of their communities, they need to acquire knowledge of beliefs and social practices. Language development is central to this process, which in itself contributes to the acquisition of culture. Deaf children born within the deaf community may be afforded the opportunity to acquire the culture of their environment, while this may be far more difficult for deaf children born into hearing families and the hearing community. This may be a factor that contributes to advantages observed for the former group in expressive language skills later in childhood (Geers and Schick, 1988), as well as in terms of social adjustment and self esteem.

2.2.2 HEARING -IMPAIRMENT AND SPOKEN LANGUAGE DEVELOPMENT

There are several problems with examining the spoken language of hearing-impaired children in comparison to the language of normal-hearing children. Understanding the complex process of language acquisition for 'normal' children is still subject to inconsistent findings and unresolved questions. Individual differences confuse the picture further, thus describing child language development in terms of progression through discrete 'stages', while useful in the evaluation of broad patterns of language development, is recognised to be a misleading and incomplete representation of the developmental process. Whilst research has proffered some relatively consistent findings which suggest that child language can be described using broadly defined categories, it is useful to bear such limitations in mind. As a result, models of typical language and communication development, which have primarily focused on the development of grammar, may not serve as useful indices by which to compare language development in hearing-impaired children. Studies specifically addressing language and communication in hearing-impaired children have tended not to focus on the same aspects of development that studies on language in normal-hearing children generally have (Gallaway, Nunes & Johnston, 1994).

Severity of hearing-impairment and spoken language development

Different levels of hearing impairment may affect the process of language development in different ways. As such, it is useful to make the distinction between children with mild-to-severe and those with profound[1] hearing losses, who will

[1] The term 'deaf' will be used interchangeably with 'profound hearing-impairment' at times for ease of reference.

differ in the amounts of useful residual hearing they may have available to them. Little research to date has looked specifically at the process of language development for hearing-impaired children (those with mild-to-severe losses), in particular those with mild or moderate hearing impairments. Instead, most studies have concentrated on deaf children, that is profoundly hearing-impaired children, who often have little or no useful residual hearing. Hearing-impaired children often have a greater degree of residual hearing which may respond well to amplification, enabling the reception of clearer and more usable auditory stimuli. It is therefore widely assumed that with good amplification and appropriate habilitation, the opportunity for these children to acquire spoken language may be optimised. However, little quantitative information exists to evidence this.

The situation may be different for deaf infants. In some cases deaf infants receive little, if any, benefit from conventional aids and it has been suggested that amplification for some members of this population may even cause disruption to the little auditory stimuli available for use by the child (Kretschmer & Kretschmer, 1986). To date it has been this population on whom many language acquisition studies have focused.

As is evident from the earlier review of the influence of early language perception on language development, hearing-impaired children are disadvantaged from the very earliest stages of spoken language acquisition in comparison to their hearing peers. Research has highlighted the role that babbling sounds appear to play in facilitating later language production. Babbling repertoires contain a wealth of syllabic information, initially produced indiscriminately by the child (canonical babbling). It has been suggested that, utilising a system of auditory feedback, children are quickly able to become acquainted with the repertoire of possible speech sounds available to them. Accordingly, their babbling sounds are observed to move towards a more differentiated repertoire by the end of the first year. Integrating this with incoming information from the linguistic environment, phonemic distinctions common to the surrounding language rapidly become differentiable, enabling the child to filter out syllabic speech characteristics irrelevant to that particular language. This is followed by the production of early phoneme combinations which act as the building blocks of the language to be acquired. It is thought that categorical perception plays an essential role in the later development of spoken language and it has been demonstrated to be established by the time a child is a few months old (Eimas, Siqueland, Jusczyk & Vigorito, 1971; Bertoncini et al, 1987).

It is accepted that these events function as precursors to linguistic development/production. Thus it can be seen that congenitally hearing-impaired and deaf children are already placed at some disadvantage for acquiring spoken language. They are unable to fully utilise incoming auditory information to recognise and reproduce the speech sounds which will be important for spoken language development, and feedback from their own vocalisations is unavailable. Although canonical babbling behaviour has been observed in even the most profoundly deaf children (Lynch, Oller and Steffens, 1989), studies have consistently reported differences in the quantity (e.g. amount of speech-like vocalisations) and quality of babbling produced by these children in comparison to hearing infants (Stoel-Gammon, 1986; Oller & Eilers, 1988). Qualitative differences have included differences in peak fundamental frequency values (height and range), syllabic variety and range of phonetic repertoires (Kent, Osberger, Netsell & Goldschmidt-Hustedde, 1987). While canonical babbling emerges at between 5 and 10 months for normal-hearing children, studies have not reported emergence before 12 months (and often considerably later) for deaf children (Steffens, Eilers, Fishman et al., 1994). Other research has reported an eventual decrease and sometimes cessation of babbling behaviour in deaf infants at a stage when the opposite is recorded for hearing infants (Mavilya, 1972).

However, it is important to note that the majority of studies examining early vocal production in hearing-impaired infants focus on severely–profoundly hearing-impaired infants. Many of these studies fail to consider to what degree observed differences are potentially compounded by the nature/degree of the hearing loss or other related factors (e.g. differences in caregiver response and environmental stimulation, influence of late hearing-aid provision and intervention). White and White (1987), for instance, provide evidence (detailed in Chapter One) that early speech production may be significantly influenced by the hearing-status of the child's parents, thus emphasising another factor that needs to be considered when interpreting findings. As well as highlighting the effects of both age of intervention and parental hearing status on the language of hearing-impaired children, they showed how these variables may interact. Thus their findings reveal that, while hearing-impaired children with hearing parents may consistently benefit from early intervention, this does not seem to be the case for hearing-impaired children with deaf parents.

Similarly, Oller and Eilers (1988) report differences in the language production of deaf and hearing infants studied. However, they fail to take account of the possible influence of the age at which the deaf children received intervention for their impairments. Robinshaw (1994) draws attention to this fact and demonstrates that if 'age of onset of amplification' is allowed for in interpreting the data from Oller and Eilers' study, a diminution of differences between deaf and hearing infants is found. And in her own studies, Robinshaw (1993) suggests that if intervention is provided within the first few months of life, metaphonological characteristics of the early vocalisations of deaf infants may be similar to those of matched hearing peers.

A closer examination of other data sets reveals that findings should be extrapolated with care. For the six deaf infants included in a study by Steffens et al. (1994) a wide range of hearing-aid experience is apparent (3–23 months). In addition, the authors emphasise that early vocal behaviour is extremely variable within, as well as between, individuals. The quantity and the content of vocalisations produced by an infant fluctuates daily. These combined sources of variance make it difficult to determine clear patterns of influence and interaction in infants' early vocal productions.

Alternatively, Pettito & Marentette (1991) have shown that, in circumstances where children are exposed to sign rather than verbal language from birth, a form of manual babbling is exhibited by the infants that is comparable to vocal babbling. They suggest that young infants are predisposed to produce babble, in accordance with an innate language capacity. In the absence of vocal feedback encouraging this process, the child is able to make use of other environmental stimuli which will enable the process to occur in an alternative modality (the visual-gestural). This observation is further supported by evidence for a continuum of parallels between the information conveyed in the visual and auditory modalities (Erting et al., 1990).

Even in the absence of appropriate non-verbal input, studies by Goldin-Meadow (1990) suggest that hearing-impaired children are able to spontaneously develop and combine gestures in order to signal particular messages. These gestures were observed to be used consistently, to be combined in semantic relations similar to those found in early child speech and to have similar morphology to that occurring in sign languages (Goldin-Meadow & Mylander, 1990). Goldin-Meadow distinguished between three types of sign in her study: deictic signs (usually pointing to signify entities e.g. there, that, mummy); characterising signs (with verb- and adjective-like properties having a clear visual relationship to their referent), and markers (negation, affirmation and conversation controllers such as a hand signal for 'wait'). Goldin-Meadow proposed that these signs were not used randomly by the deaf infants in her study. Moreover, the gestures did not seem to be derived from mimicking parental use of gestures. Only a third of gestures used by the children were found to be used by their parents, and of those, few were combined or consistently ordered. However, it has been suggested that these findings may be illustrative of the researchers' rich interpretation of the communication observed, and other investigators have failed to find supporting evidence for such a language development system (Volterra, 1983; Gregory and Mogford, 1981).

Stark et al. (1993), in a study focusing on the development of early vocal communication in normal-hearing infants, proposed that communicative skill is multifaceted and thus incorporates the integration of subsystems from linguistic, cognitive and social development. As such, hearing impaired children in receiving degraded or impoverished input in one subsystem, are disadvantaged in their development in another subsystem (such as speech).

There is evidence that children with mild-to-severe hearing impairments may process auditory and linguistic information, which underpins accurate speech perception, differently to hearing children (Jerger, Martin, Pearson and Dinh, 1995). The inter-dependence of auditory and linguistic information in speech processing has been widely demonstrated. Jerger et al. (1995) found that, when asked to selectively attend to specific dimensions of speech stimuli, hearing-impaired children seemed to process linguistic information – word input in their experiment – abnormally. However the auditory dimension, in this case talker-gender, appeared to have normal strength of processing; i.e. children had more difficulty ignoring the auditory dimension of stimuli, as would be anticipated. Normal interference was not observed for the linguistic dimension, implying that the hearing deficit somehow interferes most with later linguistic processing. Hearing-impaired children can thus make general auditory discriminations, but may have problems discriminating spectral cues related to linguistic properties (phonemes and words).

Kuhl et al. (1992) suggest that 'perceptual maps', determined by linguistic experience, are formulated in infants as early as 6 months of age. Ordinarily, by this age children will have experienced thousands of instances of speech units. Suggestive of this is the fact that the stored representations of 6 month old infants raised in Sweden, America and Japan are shown to differ accordingly, reflecting the influence of the infants' experience of their linguistic environments. Kuhl (1994) provides evidence that infants as young as between 12 and 20 weeks of age begin to imitate vowel sounds heard for brief (15 minutes) periods of time. According to his theory, acoustic boundaries are then manipulated so that speech representations are altered by, as much as they may themselves alter, speech perception and production. The infant's perceptual system at this stage is said to have already organised itself around language-specific phonetic categories. Given the dynamism of this relationship, it might be suggested that these perceptual maps must be markedly different for infants with limited, distorted or negligible incoming linguistic information.

2.2.3 Spoken language development: Delay versus deviance

Many researchers have endeavoured to look specifically at the effects of hearing impairment on spoken language development beyond the earlier stages. Many of these studies tend to concentrate on the speech patterns and language comprehension of older children with severe or profound losses (>85 dB HL) (Markides, 1983; Quigley et al., 1974, 1977). However, a common feature of studies in this area is that they often suggest that language in deaf and hearing-impaired children is either delayed, or that it is deviant.

Delayed language typically follows a slower but nevertheless normal global pattern of language development, resembling earlier stages observed in normal-hearing populations. With disruption to language development, the language diverges from the paths of normal language development and may be characterised by unusual constructions not typically observed in children's language.

It is widely assumed that greater hearing loss leads to greater speech and language disruption, yet a number of studies have failed to report a significant negative correlation between hearing level and language attainment (Davis et al., 1986; White & White, 1987; Dodd, Woodhouse & McIntosh, 1992; Ramkalawan & Davis, 1992).

Aural-oral education regimes for hearing-impaired children operate on the premise that all hearing-impaired children have the potential to develop spoken language and may do so by progressing through stages comparable to those observed in normal-hearing children, if at a somewhat slower pace. In other words, the language of hearing-impaired children is thought of as being delayed rather than deviant in these circumstances.

Gregory (1983) observed that patterns of development for deaf children can be similar to those seen in normal infants, yet delayed, and in terms of reading ability, Merrills, Underwood & Wood (1994) found that prelingually deaf readers were statistically similar to hearing children with poor reading skills. Both groups were found to be making delayed progress in reading skill. Stokes and Bamford (1990) reported, from preliminary observations of spoken communication in a small group of hearing impaired infants, a sequence of emergent linguistic communication similar to that of hearing children, yet slightly delayed. Highlighting the potential effects of rich communicative environments, Robinshaw (1993) demonstrated that emergent meta-linguistic and linguistic development can be similar to that of hearing children for severely/profoundly hearing-impaired children given early appropriate intervention, in the form of hearing-aid provision and stimulation.

Central to this was an environment conducive to supporting the child's development of communication and interaction in a sensitive and flexible manner (Robinshaw, 1993; 1995).

While several investigators have reported observations of delay in areas of receptive and expressive vocabulary skill and the syntax of hearing-impaired children's language (White and White, 1987), others maintain that for some children, language acquisition follows divergent paths of language development.

Levitt (1987), in a study of the language development of hearing-impaired children aged 10 to 18 years, concluded that delay and divergence may occur interactively, with the latter stemming from the former, as children begin to tackle advanced forms of language. It has been asserted by several researchers that such deviance is absent from the earlier stages of language development, where simple syntactical forms are observed. However, later, as a result of insufficient and inferior stimuli, deaf children have difficulties acquiring complex language syntax, and it is at these stages that deviance may be apparent.

Focusing on delay rather than deviance, Moeller, Osberger and Eccarius (1986) reported a potential increase in language delay with age for hearing-impaired children. They found that delays in receptive language and vocabulary development did not improve with age for children with severe-to-profound hearing impairments. They found delays ranging from 2 to 9 years in subjects aged 6 to 18 respectively, suggesting that the delay gap widens as hearing-impaired children get older. However, the majority of studies are unable to follow developmental progress long-term, thus differentiating between short-term delay and long term/permanent deviance in the language of these children is difficult.

A common feature of the above studies is the participation of deaf, rather than hearing-impaired, children (Levitt's study for example consists primarily of older deaf children). This may account for the findings of disruption and/or increasing delay in spoken language skill with age. More recently, studies have taken more care to differentiate between different hearing severities in examination of language development. Nevertheless, relatively few studies have investigated the development of language and communication in children with mild-to-severe hearing losses. An understanding of these processes seems particularly pertinent when we consider that these children make up the vast majority of hearing-impaired children, who will probably use hearing aids, have hearing parents and therefore begin to use aural/oral language as their primary mode of communication. Some recent studies which have focused on hearing-impaired children are reviewed below.

2.2.4 SPOKEN LANGUAGE DEVELOPMENT: RECENT STUDIES

Table 2.1 summarises the few studies which have incorporated hearing-impaired children with mild-to-severe impairments in an examination of factors related to speech, language and communication development and hearing loss since 1990.

Elfenbein, Hardin-Jones and Davis (1994) looked at the syntactic and pragmatic errors made in oral communication by hearing-impaired children. Using a combination of techniques (test battery, interview and speech sampling) they investigated oral communication skills in children with mild to severe hearing impairments and considered how these skills related to those observed for deaf and normally hearing children. They looked at forty children aged between 5 and 18 years divided into three hearing level groups: (1) children with hearing impairments less than 45 dB HL, (2) children with impairments between 45–60 dB HL, and (3) children with impairments greater than 60 dB HL. In addition, children were stratified into two groups according to age, those less than 12 years, and those 12 years or above. All children had hearing impairments which had occurred before 2 years of age, although no more precise details were provided about the ages of detection or about the aetiologies of the children's hearing impairments.

Elfenbein et al. found that hearing level had no significant influence on a number of semantic and syntactic errors found in analysed language samples. These included bound morpheme errors, verb, preposition and syntactical structure errors. However, there seemed to be a linear relationship between hearing severity and the number of phonemic errors recorded. In addition, for all hearing-impaired children, poorer production of glides, affricates and fricatives were commonly observed and over half of all errors produced by children with mild-to-moderate hearing impairments were substitution errors. Even the mildest hearing losses appeared to impact on articulation (particularly of fricatives). Further comparisons suggested that the language produced by the children with mild hearing impairments was generally more similar to that produced by normal-hearing children than to that of deaf children. The authors concluded that the difficulties observed amongst the mild-to-moderately hearing-impaired children typically resembled difficulties observed in younger normal-hearing children, suggesting they are characteristic of a delay in expressive language ability rather than of deviance. In fact only one subject exhibited deviant expressive language, which the investigators suggested was most likely the result of an additional learning, or specific language, difficulty unrelated to hearing loss. Otherwise no deviant language patterns were observed in the population studied. As a result the investigators caution that other learning problems may confound the data when looking at such heterogeneous populations as hearing-impaired children.

In a similar vein, Gilbertson and Kamhi (1995) conclude, from a study of novel word acquisition in hearing-impaired children, that these children can generally be divided into two groups – normal-developing children who have a hearing impairment and language-impaired children who have a hearing impairment.

Their study looked specifically at novel word learning in a group of twenty young school-aged children (5–9 years of age) with mild-to-moderate hearing impairments. Comprehensive average hearing thresholds over 3, 4 and 5 frequencies are provided for the hearing-impaired children (mean = 42 dB HL over 3 frequencies). Data on a group of normal-hearing children, matched on the basis of receptive vocabulary knowledge, was collected for comparison. A battery of language tests were used, including the Peabody Picture Vocabulary Test (Revised) PPVT-R. On examination of the data, it was found that two subgroups within the group of hearing-impaired children were able to be differentiated in terms of performance on the language tests. While one subgroup, referred to as the 'higher-functioning subgroup', needed an average of 2.7 trials to acquire new words in one of the tests, the other subgroup ('the lower-functioning subgroup') required 8.3 trials. Significant differences were also observed between the two groups on other language and phonological processing measures, although general cognitive ability was found to be comparable for all the hearing-impaired children. The higher-functioning subgroup performed comparably to the normal-hearing control group, while the lower-functioning subgroup seemed to perform considerably below average and produce responses characteristic of language impairment. Furthermore, hearing loss was *not* found to be a significant factor in language performance, the best predictor of which was found to be the PPVT-R. There are however several factors which Gilbertson and Kamhi's conclusions fail to take into full account:

One notable difference between the two subgroups of hearing-impaired children identified by the authors is the ethnicity of the group members. Seven of nine hearing-impaired African-American children taking part in the study comprise the 'lower-functioning subgroup' of ten children. Sociocultural factors, which the study fails to detail, have been shown to be important in consideration of performance on cognitive and language tests. Therefore sociocultural influences cannot be ruled out in interpretation of the findings.

In addition, the investigators did not take into account variables relating to intervention, such as age of identification of hearing loss or age of hearing-aid fitting. They offer some defence in citing that studies have found no relationship between these variables and language ability in hearing-impaired children (Davis, Elfenbein, Schum & Bentler, 1986). However, there is evidence suggesting that factors relating to age of intervention for hearing-impaired children may account for some variance in spoken language performance (Ramkalawan & Davis, 1992; Robinshaw, 1995).

2.2.5 Early intervention

Markides (1986) compared four groups of hearing-impaired children for speech intelligibility. The children were stratified into groups by age at fitting of hearing aids, with those in group A using hearing aids by 6 months, group B between 6 and 12 months, group C during their second year, and group D during their third year. The children were matched on age, sex, age at onset, degree of hearing loss and education. It was found that the children in group A, those that had started using their hearing aids earliest, had far superior speech intelligibility to the children in the other groups. Hearing aid fitting before 6 months appeared to offer significant benefits in terms of speech intelligibility.

From a different perspective, Ramkalawan and Davis (1992) found significant negative correlations between vocabulary, amongst other language measures, and the age of intervention for a group of hearing-impaired children. Thus earlier intervention, in particular earlier referral, appeared to account for better performance on elements of spoken language. In research evaluating the outcome of intervention for hearing-impaired children, Parving (1992) concludes that early intervention appears to facilitate pre-school attendance for children with hearing impairments less than 75 dB HL, which may in turn impact on other developmental outcomes. Similarly, finding no significant differences between hearing-impaired and normal-hearing children on a number of speech measures, Ryalls and Larouche (1992) suggest that early intervention and the early use of hearing aids were amongst factors which contributed to the hearing-impaired children's "relative normality in acoustic characteristics" (p. 95). These studies suggest that failing to take factors related to age of intervention and hearing aid use into consideration may constitute a serious omission in research of this kind.

Nevertheless, the suggestion that language impairment may confound difficulties observed for mild-to-moderate hearing-impaired children is an interesting one which has been made by other researchers. Ramkalawan & Davis (1992) for instance suggest that poor spoken language development may precipitate referral and intervention for some hearing-impaired children at a stage when deficits in this area become more noticeable (i.e. young school age). This may in turn contribute to possible selection bias in subject samples. Gallaway, Aplin, Newton, and Hostler (1990) note in their subject pool of hearing-impaired children, that four children with mild-to-moderate hearing impairments also have the poorest IQ scores within their language groups. They suggest that for these children, any linguistic handicap is rendered more severe than may be predicted from their hearing impairment alone. It may be that other studies have generally failed to differentiate between children for whom poor language performance is attributable to cognitive handicap rather than hearing loss alone.

2.3 COCHLEAR IMPLANTS AND CONDUCTIVE HEARING IMPAIRMENT

2.3.1 COCHLEAR IMPLANTS AND LANGUAGE DEVELOPMENT

Cochlear implant studies provide some further tentative supportive evidence for the possible effects of age of intervention on language and speech development. Paediatric cochlear implantation programmes during the first half of this decade have produced a number of children whose language acquisition post-implantation has been the focus of careful evaluation and research. Up until quite recently, the majority of implantees were children with post-lingually acquired hearing impairments. The factors influencing the development of good spoken language, post-implantation, for these children would be somewhat different to the factors indicating a favourable outcome had the children been pre-lingually hearing impaired. However, initial programmes incorporating pre-lingually deafened children have produced promising results (Osberger, Maso and Sam, 1993).

Tye-Murray, Spencer & Woodworth (1995) found that speech production skills were better for children who had received cochlear implants before the age of five years. Younger cochlear implantees demonstrated greater speech improvement rates in comparison to older implantees, and seemed to derive more benefit (in terms of speech performance) from their implants than age-matched peers using hearing aids. The authors tentatively conclude that early receipt of a cochlear implant might result in better outcomes, but question whether patterns of progress seen for the younger children would continue or plateau over time.

One difficulty of interpreting claims for success observed with CI children is the failure of studies in this area to outline the habilitation and educational regimes provided for these children. Post-implantation training and assessment is often intense. Without access to this information, it is often difficult to evaluate what level of contribution these interventions may have made to outcomes presented. This is particularly important when CI children are compared to HA users, as the latter are often not exposed to the same level of intervention and rehabilitation.

2.3.2 CONDUCTIVE HEARING LOSS AND LANGUAGE DEVELOPMENT

As one of the most common disorders occurring in childhood, otitis media (OM) produces episodic mild-to-moderate hearing impairment. Consequently, research considering how fluctuating intermittent hearing losses such as these may impact on language and communication provides an alternative source of information relating to the effects of mild/moderate hearing impairment on development. In addition, OM is often found to accompany other more permanent forms of hearing-impairment and thus can compound deficits and related problems for already hearing-impaired children. For that purpose, findings from this area are briefly reviewed.

Insights into the impact of mild-to-moderate hearing impairment on language development has been proffered by numerous studies investigating the consequences of transient childhood middle ear disease or otitis media (OM). Several of these have focused on expressive and receptive language development. otitis media (often with effusion – OME) causes a fluctuating hearing loss which results in the attenuation of incoming sound for the child (muffled acoustic input), ranging in severity and duration. It is often recurrent and if prevalent at particular stages of childhood development is thought to lead in some cases to the disruption of subsequent language and speech development processes (Teele, Klein, Chase et al., 1990). Other reported secondary manifestations of the disorder include: behaviour and attention problems (Roberts, Burchinal, Collier et al., 1989), learning difficulties, poor academic performance, uncoordinated motor function/balance as well as sequelae linked specifically to the function and development of the auditory apparatus. The latter category includes scarring of the tympanic membrane, atelectasis and attic retraction (Maw, 1993). In a small percentage of cases, sensorineural hearing loss has been reported to occur as a consequence of OM (Harada, Yamasoba and Yagi, 1992).

Research in this area is in part prompted by the high prevalence of middle ear hearing disorders observed in young children. Rowe-Jones & Brockbank (1991) for instance suggest that up to eighty percent of young children experience at least one episode by the age of five years. Despite the prevalence of the disorder, the treatments for OME are subject to continuing discussion and debate, while its relationship to negative behavioural and cognitive outcomes remains speculative and inconclusive. While some studies draw tentative links between OME and negative outcomes, particularly for language (Teele et al., 1990; Friel-Patti, 1987), others report no evidence to support this (Roberts, 1991). The latter however appear to represent the minority.

From the studies which have established some relationship, it is difficult to establish where causal links might be, whether poor language outcomes are long-term, or what interventions might be most beneficially utilised and when. Generally, studies have proven difficult to evaluate as a result of their retrospective and often anecdotal nature (Stool, Berg, Berman et al., 1994), along with inconsistencies and insufficiencies in data collection, definitions, methodology and follow-up. Many difficulties stem from attempting to disentangle a number of covarying and interrelated factors. Some of these factors may equally account for the sparsity of studies on outcomes for hearing-impaired children generally.

Additionally studies have been criticised for their over-reliance on hearing assessments derived from medical records which, given the fluctuating and inconsistent nature of the disorder, give no real indication of the duration, frequency or severity of associated hearing difficulties. The spontaneous resolution of OME further confuses the picture – eighty-five percent of cases are estimated to spontaneously resolve without intervention within six months of onset (Zielhuis, Straatman, Rach, et al. 1990). Early intervention or early resolution (before six months) has been found to correspond to better verbal comprehension and expression (Rack, Zeilhuis, van Baarle, et al. 1991). The research indicates an at least short-term association between certain factors of OME and delayed language, particularly up to age four. Indicative factors seem to be long-duration, the number of repeated episodes, and the degree of accompanying hearing loss. Early recurrent OME has been linked to lower performance on expressive and receptive language, and to increased error in articulation and phonology. However, how long language delays observed in young children with conductive hearing problems may endure beyond infancy has been questioned. And the possible inclusion of children with additional undiagnosed developmental language disorders may have impacted on the interpretability of findings.

The relationship between language outcomes and OME is unlikely to be a direct or simple one, and the introduction of more randomised clinical trials in this area may provide more reliable data which may clarify what are at present inconsistent and inconclusive findings. Findings in this area may shed some light on the potential routes of development that may be observed in children with milder sensorineural hearing impairments.

2.4 CHAPTER SUMMARY

This chapter reviewed the process of first language acquisition and highlighted some of the factors known to impinge on that process. These included the potential role of child-directed language, language intake and individual differences.

Some of the studies concerning the acquisition of spoken language in deaf and hearing-impaired children were considered. However, there remains a small number of studies focusing primarily on language outcomes for children with mild-to-severe hearing losses. The few studies that have been conducted (see **Table 2.1**) show some consistency in reporting delay to be a common feature of language ability for hearing-impaired children when compared to control groups. And it has been postulated that specific cognitive deficits or language disorders may account for some observations of deviant language in a subgroup of these children.

While general assumptions that greater hearing loss always leads to greater difficulty in language performance underpin several investigations, studies have failed to fully explore the range of factors which may influence outcomes in this area for hearing-impaired children. In particular, studies need to look at the direct and indirect effects of variables which may influence language and cognitive outcomes for hearing-impaired children, such as age of detection, age at hearing-aid provision, hearing-aid usage, education, parental communication training, and other forms of intervention (Strong et al., 1992).

Finally, there is some evidence from the study of fluctuating conductive hearing loss in children that mild episodic hearing impairment may result in deleterious outcomes for speech and language should intervention be delayed. In addition, fluctuating conductive hearing loss needs to be considered as it frequently compounds problems for children with congenital hearing impairments. However, it is recognised that the complex interaction of variables, the difficulties of acquiring suitable research participants and the heterogeneity of groups of hearing-impaired children combine to make research findings in this area difficult to interpret conclusively.

The following questions appear to not have been thoroughly addressed within the literature:

- What influence does hearing level have on language outcomes for hearing-impaired children?
- How might age at intervention variables impact on these findings?
- How does early intervention influence language and communication for hearing-impaired children with (i) mild-moderate and (ii) severe-profound hearing impairments?
- What role does the spoken language addressed to hearing-impaired children by their major care-giver have on their language production?
- How might these factors, and others, interact to influence outcomes in these areas for hearing-impaired children?

The studies undertaken in this thesis sought to consider these questions and investigate which factors might influence language and communication in hearing-impaired children, with particular emphasis on those children with higher levels of residual hearing (i.e. children with mild-moderate hearing impairments). The influence on language outcomes of variables such as the age at detection, age at hearing-aid provision, and type of intervention was considered. The main studies are presented in Chapters Five and Seven.

Chapter Three reviews methods of child language measurement and analysis and outlines the approach used in this research.

Table 2.1: Studies investigating speech and/or language outcomes for hearing-impaired children (mild-to-severe hearing impairments): 1990 to present.

Study	Year	Subjects		Other information	Outcome Measures	Comparison groups	Main findings
		Age group (N)	Hearing Loss (dB HL)				
Elfenbein, Hardin-Jones & Davis	1994	5–18 years (40)	GP A < 45 GP B 45–60 GP C > 60 overall mean = 52	Onset < 2 years.	• verb omissions • speech intelligibility • speech and expressive language measures and errors in: • semantics, syntax, bound morphemes, verb voice/tense, prepositions, pronouns, determiners, sentence structure and production.	16 normal-hearing children aged 5–18 years	• No significant influence of hearing level • production of glides, affricates and fricatives poor for all hearing-impaired children • most errors involve bound morphemes and unstressed components of language • deviant patterns of speech observed for profoundly hearing-impaired subjects.
Gilbertson & Kamhi	1995	7;9–10;7 years (20)	5–65 dB HTL (better ear) mean = 46 (.5, 1, 2, 4 KHz)		• measures of language and phonological processing • word learning task	20 receptive language matched controls	• No relationship between degree of hearing loss and language or word-learning abilities • some hearing-impaired children exhibit symptoms of language impairment.

Table 2.1 (continued)

Study	Year	Subjects		Other information	Outcome Measures	Comparison groups	Main findings
		Age group (N)	Hearing Loss (dB HL)				
Jerger, Martin, Pearson & Dinh	1995	4;9–16;9 years (40)	33–108 mean = 69 (.5, 1, 2 KHz)	Age onset of hearing loss (< 2 years), aetiology, identification and amplification age.	• verbal/non-verbal skill • speech processing tasks - Garner task (reaction times)	90 normal hearing children, age range 3;0–15;5 years	• Linguistic dimension of speech stimuli has underdeveloped strength of processing for hearing-impaired children. i.e. hearing-impaired children able to ignore word dimension of input more easily than auditory dimension.
Ramkalawan & Davis	1992	27–80 months (16)	32–98 (better ear) mean = 62 (.5, 1, 2, 4 KHz)	SEG, age, age of intervention – age at referral, 1st appointment, diagnosis and hearing-aid fitting.	• mean length of utterance • vocabulary • proportion non-verbal utterances • proportion questions • rate of language production	normative MLU data (Wells, 1985)	• No relationship between hearing level and outcome measures • significant influence of age of intervention on some language measures (vocabulary, proportion of questions, rate of language production).

Table 2.1 (continued)

Study	Year	Subjects		Other information	Outcome Measures	Comparison groups	Main findings
		Age group (N)	Hearing Loss (dB HL)				
Ryalls & Larouche	1992	6;10–9;10 years (10)	38–90 (better ear) mean = 64 PTA (freq. range not stated)	Age hearing-aid fitting (<5 years).	Protocol of 18 speech syllables measured for: • total duration • initial consonant VOT • fundamental & formant frequencies at midpoint of vowel (mean and s.d. for each syllable compared)	10 normal-hearing similarly aged children	Differences observed between groups for: • f0, formant frequencies and duration • Individual differences in results marked Differences between hearing-impaired and normal-hearing children not statistically significant.
Strong, Clark & Walden	1994	Birth-60 months (2519)	26–100+ mean = 77 (freq. range not stated)	Demographics, type and cause of hearing loss; identification and amplification age, intervention programme start age, treatment duration and intensity.	• expressive and receptive language measures (SKI*HI Language Development Scale - LDS) • method of communication • pre- and post-intervention indicators	none	• Severity not associated with treatment duration or intensity Language scores used to model the effectiveness of early intervention: • treatment duration inversely related to hearing severity • intervention effective for all severities but some evidence that children with mild-moderate hearing loss derive more benefit from intervention.

CHAPTER THREE

CHAPTER THREE

3.1 METHODS AND TOOLS FOR LANGUAGE ANALYSIS

3.1.1 METHODOLOGICAL ISSUES IN CHILD LANGUAGE RESEARCH

There are a variety of methods and tools that have been used by language researchers for sampling and analysing children's language. The purpose of this chapter is to review some of these approaches and consider their appropriateness for evaluating language in hearing-impaired populations.

Ingram (1989) draws attention to the shortage of work which focuses on methodology in child language research and devotes the beginning of his book to a discussion of methodological issues, amongst which he includes different techniques for data collection, linguistic measurement and analysis. Techniques for data collection range from collecting spontaneous language samples in specific contexts, to employing experimental paradigms, which might focus on language production or comprehension, involve eliciting narrative or imitation, or testing responses to particular linguistic cues. Language analysis in turn may focus on phonology, syntax, semantics or pragmatics, and transcription may be orthographic or phonetic.

3.1.2 LANGUAGE SCHEDULES

To this end, a number of procedures have been formulated and standardised, resulting in numerous language and communication schedules designed to look at various aspects of child language. For example, the Early Language Milestone Scale (ELM) (Coplan, 1983); LARSP (Crystal, 1976), and Bristol Language Development Scales (BLADES) (Gutfreund, 1989) are specifically designed to monitor patterns of normal language development, while schedules such as the Language Development Survey (LDS) (Rescorla, 1989) and the Peabody Picture Vocabulary Test – Revised (PPVT-R) are more frequently used with specifically language-impaired children or those with learning difficulties. Other scales focus on the pragmatics of emergent communication, such as the MacArthur Inventory of Language Communication (Bates, 1989), and the Pragmatics Profile of Linguistic Communication (Dewart & Summers, 1988).

Many of the more readily-available standardised tests for child language analysis focus on determining at which 'stage' a child might be in his/her language development. This is described in terms of the child's achievement of some specific 'milestone' on the continuum from prelinguistic behaviour to complex grammatical usage. Many of the schedules consist of detailed phonetic evaluation within a pre-defined framework and are often designed for use with specific age groups. For instance REEL (Receptive-Expressive Emergent Language Test, 1971) and ELM are designated for use with children up to 36 months of age.

3.1.3 Analysis of Spontaneous Language Samples

The limitations of viewing child language solely in relation to achievement of milestones have been highlighted (Chapter Two), and the particular disadvantages of applying this approach to atypical subject groups, such as hearing-impaired children, have been discussed. The heterogeneity of populations of hearing-impaired children renders the utility of many of these established and more detailed measures of spoken language ability difficult. In addition, the lack of suitable numbers of hearing-impaired children of the same age mean that studies often incorporate a wider age range than many tests used in isolation suitably cover. However, the analysis of spontaneous language samples provides an alternative and accessible approach to examining language in this population, and a number of established language metrics, regularly used by researchers, may be considered.

3.1.4 MEAN LENGTH UTTERANCE, VOCABULARY AND MEASURES OF INTERACTION

Since its conception, the Mean Length of Utterance (MLU) has been frequently used as a means of indexing early language development and predicting grammatical complexity in spoken language (Brown, 1973). A measure of the average length of a speaker's utterance for a given language sample, it is accessible and easy to utilise and its correlation with other measures of syntactic development has been demonstrated by many studies (Bloom 1970,1973; Gleitman and Gleitman 1977; Wells 1985). It has been shown to be indicative of grammatical complexity and of the number and diversity of grammatical categories, and to express semantic relations and the emergence of complex constructions. Several researchers have criticised it (Crystal, 1974), while others have highlighted its value when used carefully on selected populations. Miller and Chapman (1981) found that, for a defined middle-class population of children aged 17-59 months, MLU could be well predicted from age and was a good aid to a preliminary evaluation of linguistic competence. Scarborough, Rescorla, Tager-Flusberg et al. (1991) demonstrated that, when compared to another measure of grammatical development - the Index of Productive Syntax (IPSyn), MLU scores for language delayed subjects served as good estimates of syntactic development.

Despite its extensive use, particularly in the field of child language research, MLU has several drawbacks. Both its reliability (Klee and Fitzgerald 1985) and its validity (Crystal 1974) have been questioned. As well as being sensitive to changes in setting and environment, it has been found to be of most use when measuring language which consists of simple grammatical structures. However, as MLU is applied to more complex language samples, its reliability has been found to decrease. Depending on the population being studied, it has been suggested that it can under- or overestimate a child's linguistic ability.

Scarborough et al. (1991) sought to address this question and aimed to examine the efficacy of MLU as a predictor of grammatical complexity for natural language samples. Language samples from five different groups were considered: normal pre-schoolers, children/adolescents with delayed language, children with Fragile X Syndrome (an hereditary syndrome resulting in retardation but intact language production skills), children with Down's Syndrome, and a group of autistic children. MLU was calculated from samples of spontaneous language for all groups and compared with results derived from the Index of Productive Syntax (IPSyn). The IPSyn provides an index of 56 syntactic and morphological forms for a 100-utterance language sample. It has been shown to be highly correlated with age using longitudinal data from normal pre-schoolers in mother-child dyads at various ages between 24 and 48 months (Scarborough, 1990). For all groups of children, it was found that MLU was most reliable for early stages of language development. Beyond a certain point it appeared to variably over- or underestimate linguistic competence in performers. Its correlation with the IPSyn was found to be greatest (r = .98) for language corpora of MLU below 3.0, but weaker for language corpora where the

MLU exceeded 3.0 ($r = .64$). MLU failed to reliably predict grammatical complexity as utterance length increased, thus syntactic production was found to be severely overestimated by MLU for 12% of the language-delayed children who had moved beyond the earliest stages of language development. Similarly this was observed to be the case for some of the Fragile-X-syndrome and autistic children where MLU exceeded 3.0. Overall, the problem of overestimation of productive syntax ability was least for subjects with early language delay, and greatest for the autistic subjects. However, scores for normal-language samples, obtained from 2–4 year olds, saw good agreement with IPSyn and were unaffected by methodology (i.e. no difference was found to arise whether language samples were collected longitudinally or cross-sectionally).

However, some drawbacks to the Scarborough et al. study can be identified: language samples were collected by different experimenters for each subject group, for different purposes and under different experimental conditions. For instance, different interlocutors (parent/teacher/experimenter) were involved in the interaction from which language samples were taken. The subject numbers in the groups compared varied substantially, with some groups consisting of numbers too small for any general conclusions to be made. In addition, some samples were collected cross-sectionally and others longitudinally. Also, while the correlation of MLU with IPSyn was found to decrease for values of MLU above 3.0, the correlation reported was still significant.

The validity of MLU as a measure of linguistic competence has been questioned by other investigators. Tingley et al. (1994) suggested that handicapped children's linguistic competence may be underestimated by MLU. Thus MLU cannot be relied upon in isolation to determine spoken language capability. A review of recent literature appears to confirm a view that the potential unreliability of MLU as a linguistic tool is linked to a specific cut-off value. Some place this around 3.0 morphemes (Rondal et al., 1987), while others stipulate 4 to 4.5 morphemes, and an age limit of 4 to 5 years for typically-developing children (Scarborough et al., 1991).

Support for this comes from Brown (1973) who found that his three subjects were using similar grammatical structures in their speech up to MLUs of around 4.0. Beyond acquiring an MLU of 4.0, the measure became less of a reliable indicator of the complexity of grammatical structure – syntax may become more complex without resulting in increased utterance length. Similarly, Lahey et al. (1992) used a cut-off of 4.0 morphemes to group subjects when they investigated other potentially co-varying aspects of syntactic development in child language. A narrower range of variability in the use of grammatical morphemes was found for MLUs of 4 or more, implying that a limited amount of information regarding syntactic development could be gained from MLU data above this value. Paul and Alforde (1993) found that typically-developing children usually had MLUs of 4 – 4.5 by the time they had acquired all 14 morphemes identified by Brown (1973). Acquisition of these morphemes by language-impaired children has been observed to occur in the same order, yet over a slightly longer timescale. In addition, it was found that these children needed to reach higher MLU levels before acquiring certain morphemes. Morphological learning, the researchers suggest, appears to be a particularly difficult aspect of linguistic acquisition for language-impaired children, and morphological development appears to be more closely linked to specific language learning as opposed to general cognitive development. Therefore, evidence of MLUs falling within 'normal' range does not necessarily evidence a lack of difficulty regarding grammatical morpheme acquisition. Paul and Alforde argue that 'late-bloomers', as well as children identified as language-impaired may have particular difficulty with grammatical morpheme acquisition. It seems reasonable to postulate that hearing-impaired children may fall into this category, as it has been suggested that their language is often delayed rather than deviant. And for a subset of these children, there is also the possibility that language impairment exists independently of any language difficulties that may be associated with their hearing loss.

Additionally, some recent evidence by Blake, Austin, Cannon et al. (1994), suggests that memory span exercises a constraint on certain aspects of grammatical development. They found that when 2 to 5 year old pre-school children were asked to perform a memory task (consisting of a sentence imitation task and name list repetition), their performance scores more accurately predicted their MLU scores (derived from spontaneous samples of speech) than either chronological or mental age.

MLU has been employed in studies on hearing-impaired children both as a comparative and analytical tool (Lartz, 1993), and more recently as a tool via which to match groups for expressive language level (Lahey et al., 1992). In some instances it has been adapted for use with this population. Lyons & Gallaway (1991) adapted the MLU measure for use in an examination of spontaneous speech samples from hearing-impaired children. As a result of the heterogeneity of their study group, which consisted of children with mild to profound hearing losses and ages ranging from 3 to 8 years, they devised the mean length of vocalisation/verbalisation (MLVV). This measure enabled them to distinguish those children whose utterances consisted primarily of vocalisations and/or of unintelligible utterances. The authors felt that a lack of distinction on these measures could lead to over-estimation of language production for those children with low verbal output.

VOCABULARY

Once children have produced their first word, usually between 9 and 18 months of age, vocabulary is found to expand progressively. Several studies have incorporated the expansion of children's vocabulary, or rate of word acquisition, as a rudimentary measure of their expressive language (Geffner, 1987). For instance, Nelson (1981) and Thatcher (1976) looked at the period over which a group of infants' vocabulary expanded from 10 to 50 words in order to monitor language development. Gregory and Mogford (1981) similarly utilised vocabulary growth to measure early language development in six hearing-impaired children. They looked at the ages at which these children acquired vocabulary sizes of one, ten, fifty and a hundred words, finding that the ages of emergence for each of these stages was significantly delayed in comparison to those for normal-hearing children.

INTERACTION

In focusing on language in naturalistic communication contexts, the success of interaction has become one area that researchers have attempted to evaluate and quantify. Amongst some of the characteristics variably examined in this area are contingency of responses to questions and conversational turn-taking skills –

proportion of relevant and irrelevant turns taken (Black & Logan, 1995), number of complete and intelligible utterances produced (Klee, 1992), number of words spoken/rate of speaking (Miller, 1991), and frequency of requests made (Alpert & Kaiser, 1992). Black and Logan (1995) quantified turn-taking skills and utterance types in assessing communication strategies between parents and children. They provide a number of turn-taking indices which are useful for establishing the relevance of appropriate turn-taking behaviour. These include categorising turns in terms of their responsiveness and intrusiveness.

Generally, language research has been informed by detailed descriptive in-depth case studies (e.g. Smith 1973) which derive from reports of the child's language usage and sometimes incorporate diaries via which linguistic events are carefully recorded. In addition, some studies have consisted of large numbers of subjects and language samples, comprising both cross-sectional and longitudinal data (e.g. Wells 1985). All these perspectives and approaches have contributed invaluably to research in this area.

More recently there has been a move away from reliance on standardised tests in child language research to an examination of conversational competence and the analysis of language derived from real communication contexts (Klee, 1992). Simultaneously, computer programmes have been developed which serve to facilitate the transcription and analysis of language samples. As a result, qualitative investigative approaches are increasingly complemented by quantitative approaches which enable the examination of larger samples of children's language.

3.2 LANGUAGE MEASURES

3.2.1 LANGUAGE QUANTIFICATION

Klee (1992) stresses the importance of clearly determining the value of quantitative measures of language production in the light of a potential growth of their availability and use via computer programmes. To that end, he examined a number of potential 'indices of productive language', focusing in particular on measures generated by the Systematic Analysis of Language Transcripts (SALT1) programmes (Miller & Chapman, 1986). Klee looked at how well the language measures generated by SALT related to age for normally-developing and language-impaired children, and at whether the children could be differentiated according to the measures. In other words, he sought to determine which, if any, of the measures could be used as developmental indices of language (i.e. have construct validity – correlate with age); which might be diagnostically significant (have discriminate validity), and whether sensitivity of the measures increases for specific age groups.

His study incorporated two groups of 24 children – one group of normally-developing children (n = 12) and the other of children with specific-language impairment (SLI). Data consisted of twenty-minute language samples derived from a free-play situation between the child and one parent. From orthographic transcriptions, a number of specific measures generated by the SALT programmes were looked at. These are detailed in **Table 3.1**.

Using regression analysis techniques, Klee found that some of the measures appeared to serve as good indices of language development, correlating significantly with age, and as useful diagnostic measures, distinguishing between the normally-developing and SLI children. These measures were mean syntactic length, the total number of words, and the number of different words (based on first 50 utterances) produced by the child. The total number of utterances did not appear to increase with age and thus seemed to demonstrate no construct or discriminative validity.

Klee's study however failed to consider a number of other language production variables which may be generated by the SALT programmes, and a consideration of how some of these variables may interact and/or correlate with each other is not fully explored. SALT provides the flexibility to modify and/or generate novel measures, and to code for particular linguistic markers which may be under investigation. Klee limits his evaluation to a small closed set of generated variables.

3.2.2 SELECTED LANGUAGE MEASURES

In studies presented in this thesis, spontaneous language samples were collected from subjects and analyses were conducted which enabled a set of overt language measures to be obtained. The aim of the study was not to re-evaluate linguistic theory in relation to hearing-impaired children, but to utilise these overt linguistic measures as a vehicle to addressing the question of early detection and intervention for hearing-impaired children. The selected measures constituted the outcome variables by which the attempt is made to determine if early intervention holds any benefits for hearing-impaired children.

Whilst it is recognised that the detailed analysis of individual language samples is interesting and informative about language use and function, the approach adopted to address the research question did not focus on a case-study approach. It is acknowledged that the resultant inevitable grouping of subjects may mask potentially interesting patterns of language production. However, the grouping of subjects can sometimes be important to enable factors of influence to be seen which individual differences may obscure in small case-studies.

Noting the limitations implicit in its use, it was determined that MLU could serve as a useful indicator of grammatical complexity in this study. Whilst, in common with the other measures chosen, it may not throw light upon detailed linguistic structures or acquisition processes, it was judged to have the merit of wide comprehensibility, having been extensively used and investigated in numerous studies. It is easy to implement, has been proven to be a good indicator of syntactic development in young pre-school children and gives a robust summary of much of the data. It was beyond the realms of this study to feasibly answer questions about complex language acquisition processes, or to detail the use of grammatical structure by hearing-impaired children, particularly when these processes remain to be comprehensively understood for normally-developing children. The cross-sectional nature of data collected for the research in these studies did not allow for the monitoring of emergent milestones in vocabulary growth. However vocabulary size was included as an indicator of the children's spoken language production skill.

Furthermore, few language assessment tools and formal schedules have been standardised for hearing-impaired populations. It was therefore deemed inappropriate to utilise traditional language batteries/tests, which have been standardised for 'normal' child populations. As a starting point, the studies concentrated on a larger sample of children, in order to enable comparisons between early and late aided children, and between children with a range of hearing-impairments. Therefore the research explored a finite set of quantitative outcome measures of productive language, derived using the Systematic Analysis of Language Transcripts programmes - SALT1/SALT2 (see below).

Various researchers have highlighted the need not to rely solely on language samples when assessing children's language (Miller & Ervin, 1964, Brown, 1973; Ingram, 1989). For this reason, during both studies, aspects of the Pragmatics Profile of Communication (Dewart & Summers, 1988) were selectively incorporated into a general questionnaire undertaken with the major care-giver. This provided information pertaining to the language and communication of the child from the point of view of a communicant/interlocutor.

Table 3.1: Measures generated by SALT and examined for construct and discriminative validity by Klee (1992). Abbreviations and descriptions are as presented in article.

Abbreviation	Measure	Description
TOT-UTT	Total number of utterances	General measure of verbal productiveness.
TOTCI	Total number of complete and intelligible utterances	As above but also reflective of transcriber's ability to understand child's message.
MSL*	Mean syntactic length	Mean length of utterance (morphemes) excluding single-morpheme utterances – eliminates potential pragmatic influence of single-morpheme utterances on MLU.
TNW*	Total number of words	Calculated on fixed length sample (50 utterances).
TTR*	Type-token ratio	Ratio of number of different word roots (types) to total number of words (tokens), calculated for first 100 (TTR100), 200 (TTR200) and 400 (TTR400) utterances.

* Measures found to significantly correlate with age for both normally developing and SLI children ($p<.01$). NB: Only TTR100/200 significantly correlated.

Table 3.2: Language Outcome Measures used in the studies.

All language measures were obtained for both the child and the major care-giver (in all cases the mother).

Language Outcome Measures					
Syntax		Rate		Interaction	
Abbreviation	Description	Abbreviation	Description	Abbreviation	Description
MLU*	mean length of utterance	WPM*	words per minute	PQU*	proportion of questions
VOC*	vocabulary	WDPM*/MPM	morphemes per minute	PNV*	proportion of non-verbal utterances
SIGNS	number of signs used	TUA*	total utterance attempts per minute	ABUTTS	proportion of abandoned utterances
WDROOTS	number of different word roots	UTTS.MZ	number of utterances containing mazes	unackturns	proportion of unacknowledged turns
Variations		**Variations**		**Variations**	
MLU.F100	MLU from first 100 utterance corpus	UTTS	Total number of utterances	PQU.F100	PQU from first 100 utterance corpus
MLU.L100	MLU from last 100 utterance corpus			PQU.L100	PQU from last 100 utterance corpus
VOC.F100	vocabulary from first 100 utterance corpus			PNV.L100	PNV from last 100 utterance corpus
VOC.L100	vocabulary from last 100 utterance corpus				

* Measures derived for subjects in initial study.

WDROOTS corresponds to Klee's TNW, and UTTS corresponds to Klee's TOT-UTT.

Variations: These language measures were used in the second study in order to provide indicators relating to the robustness of the cross-sectional language samples collected and to standardise the number of utterances used to derive language measures for all participants.

3.3 CHAPTER SUMMARY

This chapter reviewed some of the approaches to collecting and assessing children's language. This revealed that many of the available tools for language analysis are potentially limited in their appropriateness for use with heterogeneous hearing-impaired populations, having been standardised for use with normal-hearing children and devised to examine typical (or 'normal') developmental features of interest.

The approach of utilising computer-derived language measures was considered and the measures chosen to assess children's spoken language in the studies presented in later chapters were presented.

Small scale longitudinal case studies are invaluable in that they offer the opportunity of assessing developmental language outcomes in depth and detail. However, in order to evaluate how various factors might influence outcomes for hearing-impaired children more generally, this approach may be limited. As a result, the studies which comprise this thesis utilised an approach which aimed to provide more generalisable conclusions relating to factors of interest (e.g. hearing severity and age of intervention). They also aimed to outline strategically important questions concerning early intervention and outcomes for hearing-impaired children.

These studies thus aimed to evaluate the influence of various factors by looking at a larger sample of hearing-impaired children than a longitudinal methodology might permit. The approach adopted necessitated a more peripheral macro-analysis of the outcome variable of interest – spoken language. The following chapter overviews the methodology and procedure that were employed in the studies conducted.

CHAPTER FOUR

CHAPTER FOUR

4.1 INTRODUCTION

This chapter describes the main methodology for the studies conducted in this thesis. Two main studies were conducted in order to investigate some of the issues outlined in the earlier chapters. These focused primarily on factors relating to the effects of hearing severity and age of intervention on spoken language outcomes for hearing-impaired children. Both studies were conducted using a cross-sectional methodological framework. Where the methodology differs from study to study, those differences are detailed in the relevant chapter. The first study is detailed in Chapter Five and the second study in Chapter Seven. The following section outlines the procedure that was employed to obtain participants for the studies.

4.2 PARTICIPANTS

4.2.1 GENERAL SELECTION CRITERIA

All potential subjects were primarily targeted via the Children's Hearing Assessment Centre (CHAC) at the General Hospital in Nottingham. In the case of hearing-impaired children, this meant that all the children either had been or were still being seen and assessed by the Children's Hearing Assessment Centre and, in the vast majority of cases, were still resident in the Nottingham District Health Authority. All subjects who were invited to take part in the study were selected in accordance with the following criteria:

a. they were resident in the Nottingham District Health Authority region;

b. they were from English speaking backgrounds where the first language and the language spoken in the home was English.

Additionally, in the case of the hearing-impaired children:

c. they had no other known disabilities;

d. they had hearing parents.

More detailed subject selection criteria for the children in the first and second studies are presented in Chapters Five and Seven respectively.

4.2.2 CONTACT PROCEDURE

In both studies the same general contact procedure was employed (see **Figure 4.1**). The parents of all children were primarily contacted by mail, via CHAC, and invited to take part in the study (a copy of the standard letter template sent out to parents can be found in the Appendix). The families were requested to return an enclosed form, directly to the researcher, in a pre-paid envelope indicating whether or not they wanted to participate. Any family which did not reply to the initial mailing (with either an affirmative or negative response) was re-invited, via a second letter, similar to the first, to take part in the study.

All families, matching selection criteria and replying affirmatively to either of the two invitations, were included in the study and were contacted by phone for suitable visiting appointments to be made. In addition, the second study offered a cash incentive of £25 to participants. The decision to offer this was made (i) in consideration of the length of time for which the interviewer needed to be in the family home alone with the parent and child (approx. four hours); (ii) with a view to allowing parents to make appropriate child-care arrangements for other siblings (if necessary) for the duration of the visit, and (iii) to encourage a high participant rate.

In both studies the children of hearing-impaired families wishing to participate were compared (on age, sex and hearing level) to those of families not wishing to participate. On each occasion, independent t-tests revealed no statistical differences in age, sex or mean hearing threshold level between the two groups. However, information pertaining to education, socio-economic status or other demographic variables of non-participants was unfortunately not available for consideration. Differences between volunteers (participants) and non-volunteers (non-participants) may have been evident if comparisons were made of these variables. This is worth considering in light of evidence which suggests that there is a significant difference in terms of social disadvantage between parents who volunteer their children for studies of this sort and those who do not. According to one study, volunteers have been found to be typically more socially disadvantaged in comparison to non-volunteers (Harth & Thong, 1990).

4.3 DATA COLLECTION

4.3.1 LANGUAGE SAMPLES AND EFFECTS OF OBSERVATION

In both studies, language collection focused on the child in as naturalistic a setting as possible interacting with a close adult family member (major care-giver). In all cases, children were seen with the mother. The aim was to obtain a degree of representativeness in the language samples for the child and care-giver during this interaction.

REPRESENTATIVE SAMPLES

It might be argued that the acquisition of representative data was made more difficult by the cross-sectional design of the studies in this thesis. However, it has been demonstrated that various factors and concerns, that might affect representativeness, are not necessarily eliminated from longitudinal studies (Belsky, 1980, Wright, 1992). When representative samples of interactive behaviour are sought, several problems arise that are inherent to the various available approaches to observation and data collection. These are outlined in the following sections.

'Representative' data is assumed to give a clear picture of how interaction and language (in this case between parent and child) probably occurs at times other than when participants are being observed. However, the potentially unfamiliar process of being observed or recorded while interacting is bound to be artificial, although Belsky (1980) notes that it is likely to affect the mother more than the child.

A range of complex social factors operate in these situations. For instance, it is inevitable that the mothers taking part will be sensitive to how they are seen to interact with their child and to how well their child is seen to 'perform' during the session. Cultural variables, environmental distractions, other commitments and cognitive appraisal of the situation are amongst factors which will also influence the naturalness of the context, and the assessment made of the situation by participants. As such, an awareness of these factors and potential participant concerns was thought to be particularly important throughout the visits conducted.

Language samples can only be representative of language behaviour in certain contexts. Thus it would be unusual to expect a sample of a mother's language, derived from interaction with her child, to be *representative* of language used by her when communicating with peers in a completely different context. Following on from this, it could be argued that the samples derived from the mother-child dyads may provide fairly reliable examples of how the participants interact in a particular context, even though that context may not be one in which they frequently find themselves. However, because of the various social factors identified above, each mother-child dyad will respond differently to the situation encountered. This variable would be found regardless of the methodology adopted or the approach taken for data sampling. The potential artificiality of the situation only becomes problematic if generalisations are made about how the participants interact on all other occasions, which was avoided in these studies.

The aim here was to obtain samples of both the child's and the mother's language in a particular context - in a familiar locality in which interaction normally occurs. Nevertheless, while as naturalistic a setting as possible was sought, there could be little question that the situation would be unusual and unfamiliar to the majority of families participating. From the beginning of the session, the experimenter (interviewer) aimed to alleviate elements of concern for the parents where possible. These included assurances as to what would happen to recordings made during the session, and the fostering of a non-judgmental relaxed approach for the duration of the visit.

EFFECTS OF OBSERVATION

Wright (1992), in a doctoral thesis which looks at the effects of observation on mother-child interaction, stresses the need for a distinction to be made between 'normal' and 'natural' settings:

"A natural setting may be seen as a setting in which the participants involved in an interaction normally interact when not being intentionally observed for experimental purposes. Therefore, for a child a natural setting may be the home, the school, the playground, or the street...For studies of mother-child interaction, the natural setting is usually taken to be the child's home". (Wright, 1992, p.11)

To this end, all participants were seen at home rather than in a less familiar setting. (It was anticipated that situating the event in participants' homes would minimise the unfamiliarity of the context). In addition, when determining the day and time of interview, parents were given full autonomy to specify a time that would be both convenient for them and convergent on a usual play period at home for the child. This involved several visits taking place in the late afternoon or early evening.

The use of a video camera and audio equipment to record the interaction enabled the experimenter to refrain from acting as an 'observer' in the situation and permitted her to respond more naturally if approached or questioned during the session. This prevented the experimenter from having to be present in the room during the interaction session (in second study), or from having to assume a position in the room that would permit detailed observation and note-taking. It was hoped that this would minimise the participants discomfort and the artificiality of the situation.

The interaction session also tended to occur last during the visit. Therefore the camera and audio equipment would typically have been in the home for approximately two hours prior to this session occurring, during which time participants were able to acclimatise to their presence. In particular, it was observed that the children appeared to rapidly become bored with the initial novelty of the equipment when it had first arrived and been assembled.

While all children in the second study were seen with the mother only, a specific adult family member was not specified prior to visits made for the first study.

Recorded interactions thus incorporated the child, the mother and/or the experimenter in the first study. In some cases a sibling or other family member (e.g. a grandparent) was also present. In the second study, for purposes of standardisation, it was requested that, if possible, recorded interactions involve only the mother and child.

4.3.2 EQUIPMENT

A Panasonic S-VHS video camera was used with SVHS SE-180 cassette tapes for all recording purposes. In addition, audio recordings were made of the sessions using a Sony stereo cassette recorder with input through a Beyer radio microphone using calibrated recording levels (study 1), and a Digital Audio Tape recorder with input through a Sony microphone (study 2). A special bib was made for the children onto which the microphone could be attached and which provided a pocket into which the radio microphone pack could be comfortably placed. This enabled some freedom of movement for the child during the recorded session while ensuring the reception and recording of clear signals.

For transcription, a Panasonic NV FS1 SVHS video recorder was used. Audio recordings were transcribed using a Sanyo audio transcriber (Study 1) or a Sony Digital Audio Tape recorder (Study 2) with output via Sennheiser HD-480 headphones. All necessary cables and extension leads accompanied the equipment. A stop watch and recording sheets were also used.

In the second study, two additional stages were introduced: the IHR-McCormick Toytest was used to gain an estimate of the child's aided hearing threshold for speech sounds on the day of interview and the Annett Peg Task was administered for a measure of dexterity and dextrality. This task is relatively simple to administer and consists of the child having to move a series of pegs from a row of holes to a parallel row of holes as swiftly as possible using one hand at a time. The times taken using each hand can then be used as measures of manual dexterity, while simultaneously indicating the degree of dextrality.

The IHR-McCormick Automated Toy Discrimination test gives an estimate of the child's hearing threshold during the session. The Toy test has been shown to be sensitive and successful in enabling word discrimination threshold and mean pure-tone threshold (in the better ear) to be reliably obtained from children aged two and above (mental age) (Ousey et al. 1989; Palmer et al. 1990). It was used in the study in order that a measure of the child's 'operational' hearing level at the time of the visit might be ascertained. This assessment would permit any reduced hearing acuity (e.g. as result of additional ear infection or cold) to be considered.

4.3.3 Procedure during visits

Each visit lasted between three and four hours and generally consisted of the following stages:

i. Introductions and setting up of equipment.
ii. Questionnaire administration made up of three parts - (a) general information questions, (b) questions pertaining to aspects of communication and – for parents of hearing-impaired children – (c) questions pertaining to attitudes to services received during and after detection of child's hearing impairment.
iii. Administration of tests (Toytest and Annett Peg Task).
iv. Collection of spoken language samples via unstructured interaction session.

Although the families had been informed of the general topic of the research, they were given the opportunity to ask detailed questions only after the session had been completed. This often resulted in quite lengthy feedback about the session from parents, who in all cases reported participation to have been a welcome and positive experience.

The first stage of each visit – introductions and setting up of equipment – was important for enabling the participants to feel at ease with the experimenter and the equipment in their home. For this purpose, all video and audio equipment was positioned at the very initial stages of the session. The questionnaires were completed using an interview format with the parent, which enabled the families to familiarise themselves with the presence of the experimenter. All interviews were video and audio recorded. These two stages would normally take approximately 2 hours.

4.3.4 General background questionnaire *(see appendix).*

The questionnaire used with participants in the first study contained main sections on the following:

i. general background of the family - parental education and occupation, number and ages of siblings; child education;

ii. the detection and diagnosis and aetiology of hearing impairment;

iv. the parents' feelings about and post diagnosis;

v. the families' attitude to the services provided following the detection of the hearing impairment, and views on neonatal hearing screening.

The questionnaire used with participants in the second study was modified slightly and consisted of the following main sections for parents of sensorineural hearing-impaired children:

i. general background questions about the family - parental education and occupation, number and ages of siblings; child education;
ii. questions about the detection and diagnosis of hearing impairment;
iii. questions pertaining to the child's general health, birth details and other problems (e.g. behavioural);
iv. questions about language, communication and patterns of family interaction (adapted from Dewart and Summers, 1989);
v. questions seeking the families' attitudes to the services provided following the detection of the hearing impairment, and views on neonatal hearing screening.

Questions about any accompanying middle ear problems and about family history of hearing impairment were included. Family concerns about the child's hearing loss were also explored. Questions about language and communication included questions about social and familial interaction in light of the hearing impairment.

Detailed outlines of the questionnaires are presented in the Appendix.

4.4 Transcription of Language Samples

4.4.1 Transcription and Coding Conventions

All information from the final part of the sessions was orthographically transcribed and coded within the Systematic Analysis of Language Transcripts (SALT). Both the video and audio tape recordings were utilised for cross-reference purposes, to clarify ambiguities where they may have occurred in one form of recording. The video recordings also served to provide context and enabled the coding of non-verbal communication, gesture, and to pinpoint the focus of participant attention during the interaction. A thirty minute episode of interaction typically took 24 to 32 hours (3 - 4 working days) to transcribe, code and check rigorously, depending on the complexity of the interaction and language, and the number of participants in the recorded sample.

The SALT package (Miller & Chapman 1984; revised 1991, 1993) consists of two main computer programs, one allowing standard pre-defined language measures (e.g. mean length of utterance, proportion of questions) to be obtained for transcribed material, the other enabling the user to flexibly define explorations and set up specific search criteria. All language data were encoded so that it could be explored and analysed using the SALT programs. This enabled strict standardised coding procedures to be formulated and applied to all language transcripts, some of which were standard SALT conventions while others were specifically devised to examine certain aspects of the data.

The following is a description of the transcription and coding conventions used for all language samples collected in the studies conducted. All language transcripts were generated using the Systematic Analysis of Language Transcripts (SALT). A sample extract of a transcript is provided in the Appendix.

Following Garvey (1984), an utterance was defined as "*one person's speech bounded by pauses or by the speech of another person*". However, segmenting utterances is not always easy and straightforward, particularly if a speaker produces more than one utterance per turn. SALT claims to set a primary goal of documenting 'thought completion' in its segmentation of utterances, characterised by the rise and fall of intonation and/or the presence of a pause.

However, children's utterances often contain little change in intonation and a number of complex sentences may be conjoined without pauses between them. In these cases, in order to determine the boundaries between utterances, a combination of the factors outlined above and a consideration of the dependence and independence of clauses produced were used. In line with SALT recommendations, decisions on utterance boundaries were made with a degree of sensitivity to the speaker's intentions and the interlocutor's reaction, rather than to a strict grammatical rule.

A **turn** – was characterised by one utterance. In one of the studies, turns were coded as being acknowledged or unacknowledged. An acknowledged turn occurred when the speaker responded or initiated at an appropriate juncture (i.e. at the end of the other speaker's turn, or after a pause or question), and where the utterance had some shared thematic content with the preceding utterance. Unacknowledged turns occurred when a speaker did not respond or initiate, having been provided with an appropriate juncture by the other speaker (e.g. end of turn pause or request), provided information which was irrelevant to the preceding utterance, or did not acknowledge a statement. Inappropriate turns consisted of turns that interrupted or occurred simultaneously with another speaker's turn or failed to leave an appropriate pause for the other speaker to take a turn. Thus turns were coded within transcripts as being acknowledged or unacknowledged. In addition, utterances were coded if they were interrupted or overlapped with another speaker's utterance (i.e. inappropriate turn by other speaker).

Abandoned utterances – were coded within the transcript. The coding system permitted the distinction to be made between interrupted utterances (where a speaker was hindered from completing an utterance by the intervention of another speaker) and unfinished utterances, where a speaker failed to complete a utterance of their own accord. The latter were categorised as abandoned utterances.

Non-verbal utterances – were defined as instances where a speaker takes a turn by responding or initiating with a non-verbal act either to accompany or replace a spoken utterance. These were coded within transcripts (encased in curly brackets) and constituted a count of zero words in analyses based on word/utterance length.

Questions – were determined by the presence of a characteristic rise in intonation signifying a request for information or clarification. They could be open, allowing for prolonged response, or closed, allowing for a yes/no response.

Bound morphemes – all utterances were coded for bound morphemes according to SALT coding convention recommendations. This was also considered important in light of findings which suggest that it is with speech sounds in final consonant positions that hearing-impaired children appear to have difficulties (see Chapter Two). Therefore all suffixes, not prefixes, were encoded. Examples of the types of suffixes encoded as bound morphemes are listed in **Table 4.1** and include -ed (regular past), -s (plurality, regular third person singular and possessive), -ing (participle), -n't (negation), irregular 3rd person singular, contractible and uncontractible copula, contractible/uncontractible auxiliary.

Table 4.1: Bound morphemes encoded within transcripts (SALT, 1992).

Linguistic element	**Bound morpheme**	**Coded example**
Possessive inflections	-s, -'s	***Mum/z*** book
Plural noun inflections	-s, -es	My ***book/s***
Plural and possessive inflections	-s'	The ***father/s/z*** books
Third person singular verb	-s, -es	Mary ***go/3s*** home
Regular past tense	-ed, -d	Mary ***like/ed*** John
Participle	-ing	John was ***play/ing*** outside
Contractible verb forms	-'m, -'s, -'ll, -'re, -'ve	***I/'ll*** do it tomorrow
Negative contractions	-n't, -'t	I ***can/'t*** find the book
Exceptions	adjectival forms of bound morpheme, predicate adjectives and gerunds.	*swimming* pool; I'm *bored*; *playing* is fun

Codes – All instances of sign or gesture used to support spoken language were coded by the insertion of the code [+sign] on the utterance line contingent with the spoken utterance signified. Consonantal errors were coded by the following:

[OF] omitted final consonant

[OI] omitted initial consonant

[SI] substituted initial consonant

[SF] substituted final consonant

[SCl] substituted cluster

Pauses – (between and within utterances) and timing information were detailed within transcripts for the calculation of measures related to the rate of language production and interaction. Differentiation was also made between pauses which were followed by a change in speaker turn and those which were not, thus allowing for the examination of relevance and appropriateness in turn-taking behaviour.

Mazes – all instances of false starts, repetition or reformulations were coded and were not counted as part of an utterance. This was done in order for utterance length not to be inflated in instances where a child's utterances consisted of a large number of mazes. Within themselves, the frequency and length of mazes provides interesting information pertaining to utterance formulation and word production, and as such a measure of the number of utterances containing mazes (UTTS.MZ) was calculated from transcripts for all participants.

Fixed or rehearsed phrases lifted from titles, rhymes, television or parental utterances (e.g. counting) were coded so that they would count for only one utterance, and like mazes, would not inflate utterance length and other language measures.

Unintelligible words – were represented within the transcript by 'xxx'. Partial and incomplete words were transcribed by a phonemic representation of the intelligible part of the word, with the code (above) for unintelligibility representing the rest. For the hearing-impaired subjects, words were categorised by their consistent use by the child to refer to an object or event, and in consideration of the interpretation of the child's listener. As all child language samples were collected from parent-child interactions, it was deemed appropriate to consider a production to be a word if interpreted as such by the parent, even if unrecognisable to the transcriber. Phonetically consistent forms were also encoded. After Fletcher and Garman (1979), these were defined as "an utterance or part of an utterance that fails to approximate the adult form and does not show consistent application to objects or situations but which tends to be stable in production with a distinct prosody". It would be anticipated that younger participants may produce these.

Unacknowledged turns – At times, a natural turn would become available for either participant which would not be acknowledged. The smoothness of conversation relies to some degree on participants both initiating and acknowledging turns appropriately. When either speaker failed to acknowledge a turn, this was coded as an unacknowledged turn within the transcript.

4.4.2 Intertranscriber reliabilities

A subset of the recordings was independently transcribed by a second transcriber. Standard language measures were extracted from each transcription and comparisons were made between transcripts. Correlational analyses were used to assess inter-transcriber reliabilities. Correlations ranged from 0.78 to 0.95 ($p<.05$) for comparisons made of language measures derived for both children and mothers by each transcriber independently.

4.5 Chapter summary

This chapter described the main methodological framework employed for the studies described in this thesis. The procedure for contacting subjects was outlined, along with the method and equipment used for acquiring language samples. Some of the issues surrounding the acquisition of 'representative' language samples and some of the potential effects of observation on participants' interaction were discussed. All language samples were transcribed using the Systematic Analysis of

Language Transcripts programmes. The transcription and coding conventions employed during this process were outlined.

Two main studies were conducted to investigate factors relating to the effects of hearing severity and age of intervention on spoken language outcomes for hearing-impaired children. The first study, presented in Chapter Five, investigated the effects of these variables on outcomes for a group of young hearing-impaired children who were stratified according to the severity of their hearing impairments (mild-to-profound). This study considered the feasibility and limitations of such an investigation as well as the efficacy of the chosen methods of data collection, analysis and linguistic measurement.

The design of the second study was such that it aimed to incorporate children with (i) conductive hearing-impairment, (ii) sensorineural hearing-impairment and (iii) normal-hearing. As a large proportion of hearing-impaired children spend time after birth in neonatal intensive care, this was included as an additional stratifying variable. Thus attempts were made to stratify children according to whether or not they had spent time (longer than 24 hours) in the Neonatal Intensive Care Unit (NICU) immediately following birth. However, the small number of subjects in some cells meant that this initial design had to be modified. In particular, finding sufficient numbers of children (as determined by power analysis) for the sensorineural hearing impairment/NICU category who did not have additional complicating factors, proved difficult.

Figure 4.2 summarises the groups and numbers of children who eventually comprised the subjects of the studies.

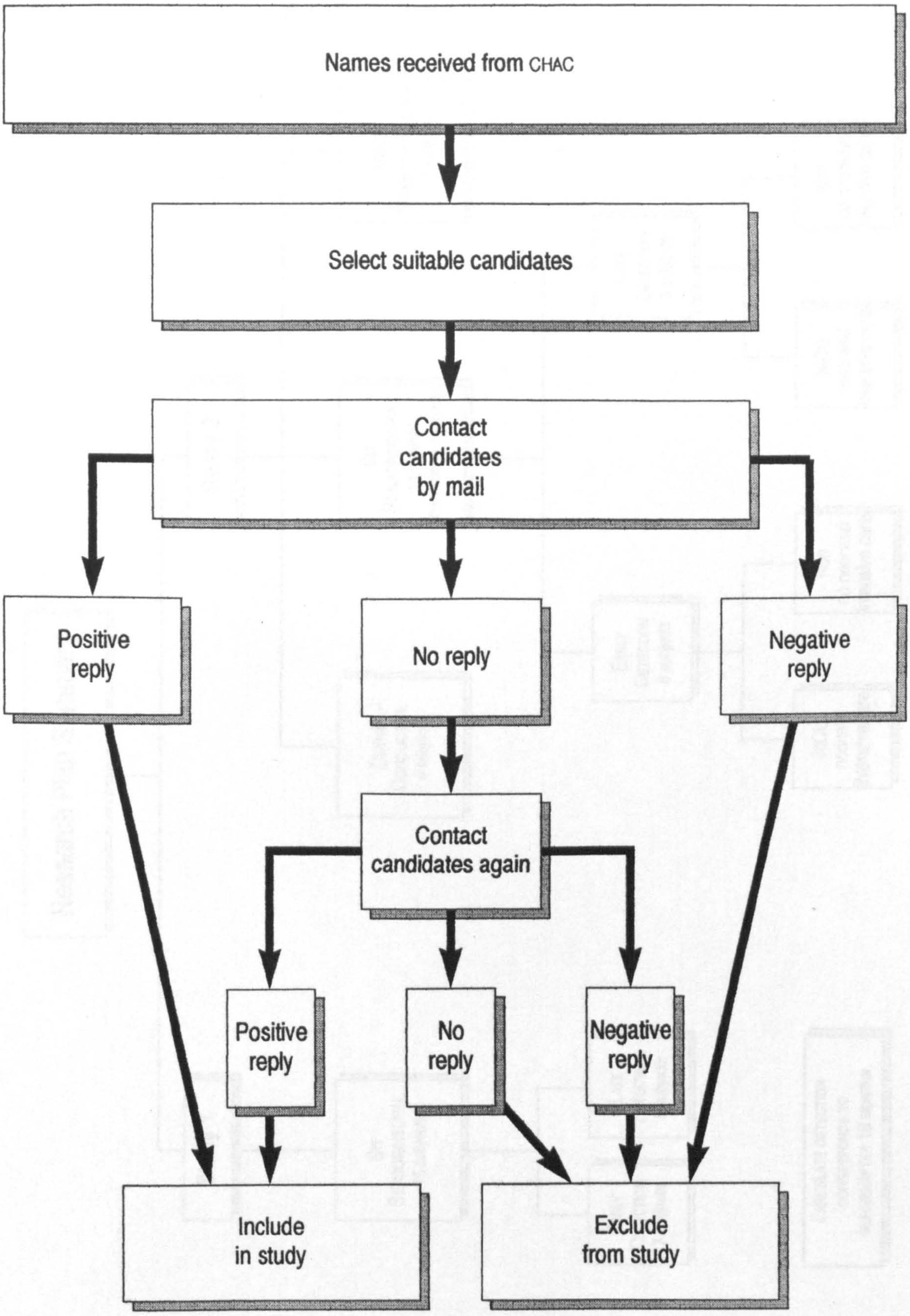


Figure 4.1: Subject contact procedure.

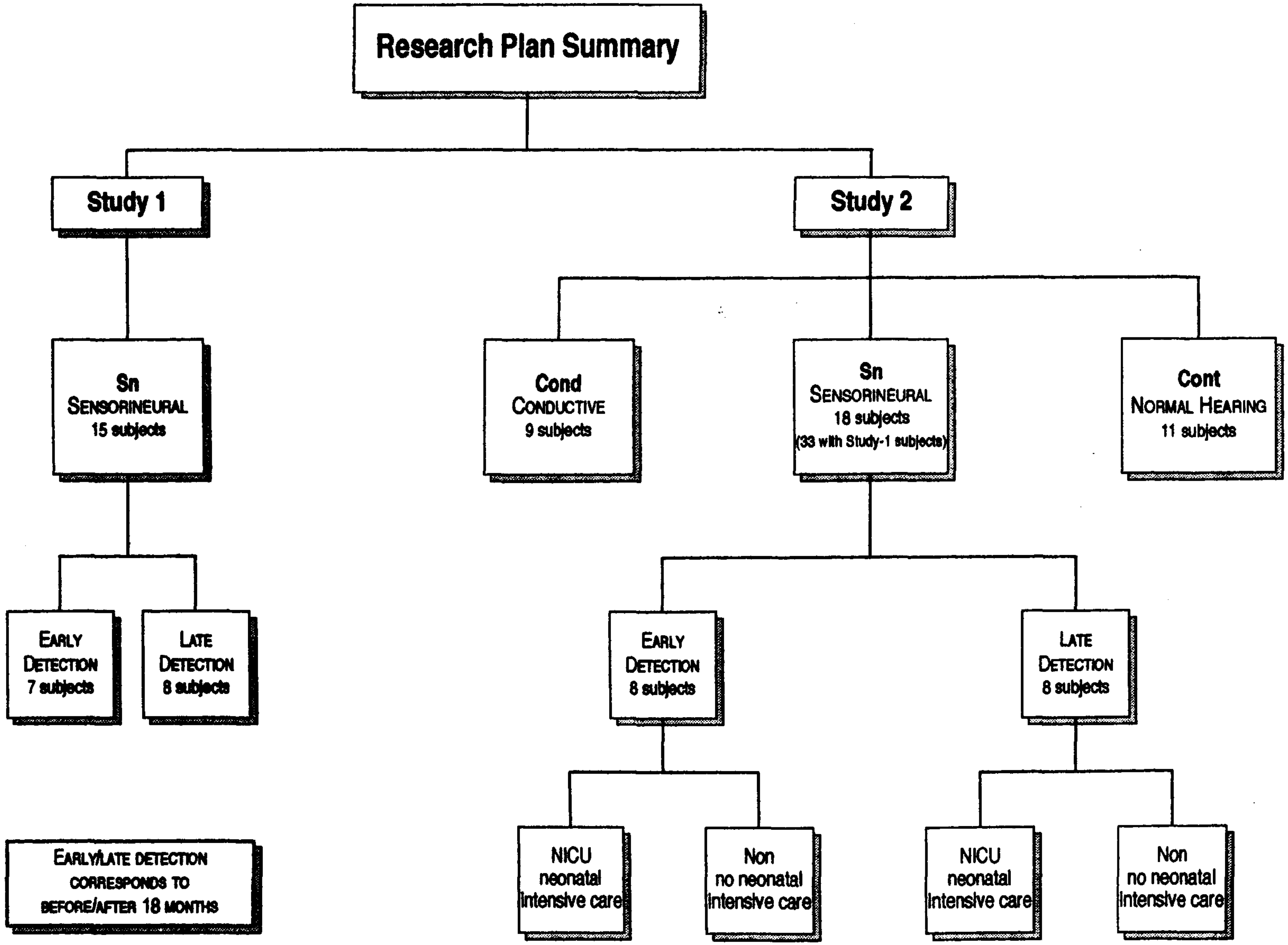


Figure 4.2: Research plan summary.

CHAPTER FIVE

GLOSSARY OF ABBREVIATIONS

LANGUAGE MEASURES

MLU	mean length of utterance
PNV	proportion of non-verbal utterances
PQU	proportion of questions
TUA	total utterance attempts per minute
VOC	vocabulary
WPM	words per minute
WDPM	words per minute (TUA x MLU)

DEMOGRAPHIC VARIABLES

AGE	age of child at time of participation in study
AGE.APP	age of child at first appointment at CHAC
AGE.DET	age of child at time of initial detection
AGE.FIT	age of child at hearing-aid fitting
AGE.REF	age of child at time of referral to CHAC
SEG	socio-economic group

OTHER

BEA	Better Ear Average
dB HL	Decibels Hearing Level
CHAC	Children's Hearing Assessment Centre (Nottingham)

CHAPTER FIVE

5.1 INTRODUCTION AND METHOD

The aim of the first study was a preliminary investigation of the spoken language abilities of a group of hearing-impaired children in relation to a) the severity of their hearing impairments and b) the age at which intervention was received for their hearing impairments.

5.1.1 CONTACT OF PARTICIPANTS

A group of sensorineurally hearing-impaired children satisfying the criteria outlined in Chapter Four were selected from records at the Children's Hearing Assessment Centre. Forty-eight children in total were targeted for inclusion to the study and were invited to take part. All subjects had congenital sensorineural hearing impairments ranging from mild to profound (i.e. 30 to 117 dB HL) and were selected on the premise that they had no other major problems in addition to their hearing loss.

All families were informed of the study by post and invited to take part. Of the forty-eight families initially contacted, twenty (42%) agreed to take part in the study. (Second invitations were not administered and subjects consisted of respondents from the initial mailing only). Basic information relating to age, sex and hearing level was available for all the children invited to take part in the study, thus allowing comparison between those who chose to take part and those that did not. Using independent t-tests, the twenty children whose families agreed to take part in the study were found not to differ statistically in age, sex, or hearing level from those that chose not to take part in the study ($p>.05$).

The subjects of this study thus consisted of twenty children, ten boys and ten girls, ranging in age from 15 to 79 months (mean = 56 months). Nineteen of the subjects had congenital sensorineural hearing impairments, while one, subsequent to inclusion, was found to have an acquired pre-lingual sensorineural loss. This child was however retained in the study as a result of the pre-lingual nature of his impairment. Two children were also suspected of having progressive hearing impairments, although this was unapparent at the time of this study.

All subjects had hearing parents and all of the children had spoken English as their first language. However four of the profoundly hearing-impaired children were, during participation, observed to be relying mainly on a manual system of language and communication. The parents of these children had all chosen to communicate with their children using sign language and were themselves learning British Sign Language at the time of the study. The needs of, and developmental issues pertaining to, hearing-impaired children with low verbal output are important, however it was beyond the capacity of the studies presented here to address this issue. The scope of this project did not incorporate detailed investigation of the use of sign language by hearing-impaired children, and aimed to focus specifically on the use of spoken language. Therefore, data from these four children were excluded from all analyses presented and are included in none of the results. The potential impact of these exclusions on reported findings is considered in the discussion.

5.1.2 PARTICIPANT DETAILS

The final group of subjects thus consisted of 16 children with bilateral sensorineural hearing-impairments. Their ages ranged from 27 to 79 months (mean 57, s.d. 16) and their hearing impairments ranged from 32 to 98 dB HL (mean 62, s.d. 19) in the better ear averaged over the frequencies 500 Hz, 1 kHz, 2 kHz and 4 kHz. All hearing assessments were conducted at the Children's Hearing Assessment Centre (CHAC) and thresholds were determined by means of pure tone audiometry where the children were of sufficient age and cognitive development. Alternatively, Performance, Co-operation, Distraction and/or Visual-Reinforcement tests of hearing were used to ascertain thresholds for the younger children. Recorded hearing levels are derived from hearing assessments conducted as near to the date of interview as possible for each individual child. The Appendix contains detailed audiological profiles of the children. These include details of the children's hearing-impairments, aetiology (where available), and pure tone thresholds derived from audiological assessments conducted as near to the time of interview as possible. Dates of referral, first appointment and hearing-aid fitting are also detailed there. The children had been using bilateral hearing aids for an average of 28 (s.d. 19) months at the time of the study.

5.1.3 Aetiology of Hearing-Impairments

The aetiology of hearing impairment for each child was ascertained from medical records at CHAC and at the Nottingham City hospital where appropriate. In six cases (37.5%) aetiology was unknown; in eight cases (50%) a genetic cause was suspected (autosomal recessive for one child, and autosomal dominant for another was confirmed), while in the remaining two cases (12.5%) suspected aetiology was rubella infection of the mother.

5.1.4 Socio-Economic Grouping

A measure of the socio-economic group (SEG) was derived from the occupation of the main wage-earner (head of household) for each family involved in the study. SEG was represented by categories 1 – 5, in which 1 relates to professional/managerial occupations, 2 to skilled occupations, 3 to semi-skilled occupations, 4 to unskilled occupations and 5 categorises unemployment. This corresponds to the codes outlined in the UK Registrar-General's Classification for Socio-Economic Groups (OPCS, 1990), which were referred to in detail in the determination of SEG.

5.1.5 Age of Intervention

Age of intervention was represented by four measures. These are the age of the child, (1) at the time hearing impairment was first detected, (2) at referral, (3) at first appointment and (4) at the time of hearing-aid fitting. These are presented in **Table 5.1**. All figures were derived from records at CHAC and were cross-checked against parents' subjective records of the age of their child at each of these events to ensure that there were no marked discrepancies or inaccuracies in the records.

Table 5.1 – Subjects of study 1, their ages and hearing threshold levels (averaged over 0.5, 1, 2, 4 kHz) in the better ear (BEA). The means and standard deviations for the 16 subjects are also presented. Age of intervention in months is illustrated by: age of child when hearing loss first detected (age detn), age of child when referred for assessment (age referral), age of child at time of first appointment (age 1st app), and age of child when hearing aids fitted (age fitting). The delay (in months) between age of detection and age of fitting is also presented.

NAME	SEX	AGE (m)	AGE DETN	AGE REFERRAL	AGE 1ST APP	AGE FITTING	DELAY (m)	BEA dB HL
BB	*male*	*15*	*7*	*7*	*7*	*8*	*1*	*100*
SW	*female*	*33*	*10*	*11*	*11*	*12*	*2*	*95*
AH	*male*	*61*	*1*	*1*	*2*	*3*	*2*	*117*
LM	*male*	*62*	*4*	*7*	*8*	*9*	*5*	*105*
IF[1]	male	27	11	11	11	16	4	55
TW	male	32	9	10	11	27	18	74
JA	female	37	8	13	14	33	25	52
KWo	female	47	2	2	2	18	16	81
VR	male	53	8	10	11	16	8	40
CN	male	54	30	39	41	42	12	48
JH	female	57	4	9	9	11	7	98
AA[2]	male	57	30	33	34	36	6	61
SB	female	61	18	37	38	39	21	68
KWi	female	61	35	44	44	44	9	40
JCa	female	65	14	14	16	17	3	78
TH	female	67	36	37	43	44	8	32
WW	male	69	36	48	52	54	18	80
DA	male	73	4	9	11	27	23	58
KH	female	74	6	7	13	18	12	65
JCl	female	79	13	13	13	22	9	72
MEAN		**57**	**17**	**21**	**23**	**29**	**12**	**62**
MEDIAN		**59**	**13**	**13**	**14**	**27**	**12**	**63**
S.D.		**16**	**13**	**16**	**16**	**13**	**7**	**19**

italics = children (with profound losses and low verbal output) excluded from all analyses. These children are excluded from mean and median measures presented.

[1] Child has Down's Syndrome

[2] Child later found to have progressive hearing loss

There was a great deal of variance in the ages of intervention reported for the children, demonstrating one area of typical heterogeneity for hearing-impaired participants. The earliest age of detection amongst the children in this sample was 2 months (KWo) and the latest age of detection is 36 months (WW) (group median = 13). Age of referral ranges from 2 to 48 months (group median = 13), age of first appointment from 2 to 52 months (median = 14), and age of fitting ranges from 11 to 54 months (median = 27). The delay between age of detection and age of hearing-aid fitting for this group ranges from 3 to 25 months. As can be seen, early detection, referral and first appointment did not necessarily guarantee early hearing-aid fitting for a variety of reasons which are outlined later. The child who was detected earliest was also referred and had a first appointment earliest, at 2 months. However, she was not fitted with a hearing aid until 18 months of age, 16 months later. Taking the median values for age of intervention, it can be seen that the largest delay appears to occur between age at first appointment and age at hearing aid fitting (13 months).

5.2 Data collection

5.2.1 Materials

Materials used were as detailed in Chapter Four (*4.3.2*).

5.2.2 Procedure

All children were visited once in their own homes by the same interviewer. At all times the child was seen with the major care-giver, which in all instances was the mother. The camera and audio equipment were set up for recording; meanwhile, the child became familiar with the interviewer and the situation. The interviewer conducted a background information questionnaire with the parent which included questions about the child's communication skills (after Dewart and Summers, 1988) and questions relating to services provided (see 4.3.4). All responses were recorded via both audio and video tape. This stage lasted approximately 45 minutes.

The final session consisted of approximately 35 minutes of unstructured play involving, on most occasions only the mother and child. In some circumstances, this also included the interviewer and other siblings when they were present. During the unstructured play session, the participants were free to engage in whatever activity they wished. Typically this involved shared reading and/or the playing of games. In the event that subjects engaged in prolonged shared reading, the interviewer would intervene and encourage participants to engage in some other activity for some part of the session. This ensured that transcripts/language samples were not derived solely from the structured interaction which typifies shared reading between parent and child.

From this period of unstructured play, a sample of the study-child's language was drawn for analysis. Every child whose language was included in analyses produced at least 100 consecutive utterances. The number of utterances produced during the period of recording ranged from 120 to 579.

Whilst realising that recording on a single occasion might render results which are unrepresentative of a child's normal linguistic capacity, care was taken to establish that any sample obtained was reasonably representative of the child's performance on other occasions. This was achieved by playing back part of the session to the mother and asking whether it was a 'typical' interaction or whether the child was more inhibited or active than usual. In all instances it was reported that the recorded session was at least reasonably representative of the child's ordinary communication in similar contexts.

5.2.3 TRANSCRIPTION

Language samples were transcribed for all participants (children and parents) using both audio and video recordings. The video recordings served to provide context and to resolve ambiguities in the audio recordings. The utterances of all participants were transposed onto computer using SALT programmes (Systematic Analysis of Language Transcripts – Miller and Chapman 1984; revised 1991, 1993). SALT was also used to code and analyse transcripts according to the conventions and criteria outlined in Chapter Four for the language measures detailed below.

5.2.4 LANGUAGE MEASURES

From the transcribed language samples, six measures were derived for each child. These were the mean length of utterance (MLU), vocabulary (VOC), total utterance attempts per minute (TUA), words per minute (WPM), proportion of non-verbal utterances (PNV) and proportion of questions (PQU). An additional measure of words per minute (the product of TUA and MLU – WDPM), was calculated externally to SALT. The means and standard deviations for the language metrics are shown in **Table 5.2**.

Table 5.2 – Subject language scores. Means, medians and standard deviations are also presented.

NAME	AGE (months)	SEG	BEA (dB HL)	MLU (morph)	VOC	PNV %	PQ %	TUA	WDPM	WPM (salt)
IF	27	1	55	1.1	4	83.5	0.0	3.8	4.2	0.7
TW	32	4	74	1.2	29	36.7	3.3	6.7	8.2	5.3
JA	37	2	52	2.9	184	0.5	4.2	6.5	18.9	17.7
KC	47	4	81	1.9	171	21.9	7.1	16.7	31.0	24.4
VR	53	2	40	3.3	182	15.0	6.4	9.4	30.7	25.5
CN	54	4	48	2.3	294	2.1	1.7	10.4	23.4	22.5
JH	57	1	98	4.3	264	6.9	7.3	6.3	26.9	23.6
AA	57	2	61	3.3	147	1.2	2.4	8.2	26.9	24.8

(continued overleaf)

Table 5.2 (continued)

NAME	AGE (months)	SEG	BEA (dB HL)	MLU (morph)	VOC	PNV %	PQ %	TUA	WDPM	WPM (salt)
SB	61	4	68	2.6	173	13.2	3.7	5.5	14.7	12.3
KW	61	5	32	2.0	147	4.1	7.7	8.6	17.5	15.8
JC	65	4	78	2.2	317	1.2	10.6	11.9	25.6	23.8
TH	67	5	32	2.3	194	0.4	3.5	12.7	28.8	27.7
WW	69	3	80	2.8	150	4.3	10.1	10.0	28.1	25.3
DA	73	5	61	3.1	252	4.0	7.6	9.0	28.0	26.2
KH	74	2	65	3.0	233	3.0	12.6	16.2	48.7	45.5
JCI	79	3	72	4.1	242	15.6	11.3	10.3	42.8	33.4
MEAN	**57**	**-**	**62**	**2.7**	**186**	**13.3**	**6.2**	**9.5**	**25.3**	**22.2**
MEDIAN	**59**	**-**	**63**	**2.7**	**183**	**4.2**	**6.8**	**9.2**	**26.9**	**24.1**
S.D.	**16**	**-**	**19**	**0.9**	**85**	**21.1**	**3.7**	**3.6**	**11.3**	**10.5**

All these measures were also obtained for the care-givers who interacted with the children during the session. In all cases this was the mother of the child. This provides data pertaining to the linguistic input received by the child during the session and the patterns of communication arising between care-giver and child. This information is presented and examined in more detail in Chapter Seven. Below is an examination of the language measures for the children's language in relation to the main variables of interest - hearing threshold level and age of intervention.

5.3 RESULTS

5.3.1 CONSISTENCY IN LANGUAGE SAMPLES

It was important to establish at the outset that there were no important methodological problems due to the cross-sectional nature of the interview schedule, or to the presence, in some cases, of other children during recording.

Firstly, each child's transcript was separated into two halves and a subset of the language measures (MLU, VOCABULARY, WPM) were derived from each. Paired samples t-tests revealed no significant differences between the measures derived from each language corpus. Thus there seemed to be no substantial fatigue or warm-up effects over the course of the recorded episode.

Secondly, there was no significant main effect on subjects' language measures as a result of having another child present during the recorded play session. A comparison of all seven language metric means, between children who had siblings present and those who did not, showed no significant differences.

5.3.2 EFFECTS OF AGE AT INTERVIEW

Correlational analyses were deemed the most appropriate way to investigate relationships between the independent (age, hearing level, age of intervention, demographic variables) and dependent variables (language metrics). Significant positive correlations ($p < .05$) were found between age and the language metrics MLU, WDROOTS, WPM, TUA, and PQU. A significant negative correlation was found between age and PNV. Thus, as might be anticipated, all the spoken language scores consistently increase with age, except PNV, which decreases with age.

Correlations ranged from .53 ($p < .05$) between age and total utterance attempts per minute (TUA), to .78 for words per minute (WPM) ($p < .005$) and are presented in **Figures 5.1 to 5.7**. These figures illustrate the bivariate correlations between age and the language measures: MLU, WDROOTS, WDPM, TUA, WPM, PNV, and PQU. In each figure the language measure can be seen to increase with age.

Multiple regression confirmed that the age of the child at the time of interview was the strongest predictor for all language outcome measures ($p < 0.01$) accounting for over half of the variance for some of them (adjusted r squared = .56 for PQU and .55 for WPM). In all subsequent analyses age at interview was therefore statistically controlled when deriving other correlations of interest (between the language measures and hearing level, age of intervention, and other demographics). These can be derived from correlational matrices, or from regressional analyses (in this case multiple regression), where regression equations are calculated, modelling the interactions between the predictors (independent variables) and criterion (dependent variables).

5.3.3 EFFECTS OF AGE OF INTERVENTION

As a result of the significant influence of age on the language measures, statistical explorations of the relationship between age of intervention and the language scores necessitated that age be statistically controlled for.

Calculated partial correlations between the language scores and ages of intervention, controlling for the age of the child at interview, are presented in **Table 5.3a**.

Table 5.3a – Partial correlations found between the language measures and (i) age of intervention (i.e. age of detection, referral, 1st appointment and hearing aid fitting) and (ii) hearing threshold in the better ear, controlling for age at interview. For vocabulary (VOC) a quadratic function in age was used to control for age at interview.

Language	Ages of Intervention (months)				Hearing
Metric	**Detection**	**Referral**	**First App.**	**Fitting**	**level**
MLU	-0.36	-0.29	-0.33	-0.33	+0.28
TUA	-0.17	-0.30	-0.26	-0.19	+0.00
WPM	-0.37	-0.48*	-0.43	-0.38	+0.05
WDPM	-0.47*	-0.60*	-0.56*	-0.50*	+0.15
PNV	-0.18	-0.25	-0.25	-0.35	+0.12
PQ	-0.53*	-0.55*	-0.54*	-0.48*	+0.46*
VOC	-0.47*	-0.49*	-0.48*	-0.46*	+0.24

* $p < 0.05$, N=16, df = 13

These show that the ages of intervention – represented by measures of the age of the child at (1) detection, (2) referral, (3) first appointment and at (4) hearing-aid fitting – have negative partial correlations with all the language measures. These correlations are significant ($p < 0.05$) in the case of (1) the number of words per minute – WPM (r ranges from -0.46 to -0.59 respectively), (2) the proportion of questions asked by the child – PQU (r ranges from -0.44 to -0.52) and (3) the vocabulary of the child – VOC (r ranges from -0.45 to -0.51). Thus the lower the age of intervention, the better the outcome measures for language were found to be for these variables. **Figures 5.8 to 5.11** illustrate some of the relationships found between the language measures and ages of intervention: PQU is presented as a function of age at referral (Figure 5.8), first appointment (Figure 5.9) and hearing-aid fitting (Figure 5.10), and WDPM is presented as a function of age at hearing-aid fitting (Figure 5.11).

Figure 5.12 illustrates the partial correlations found between the ages of intervention and the language measures PQU and WPM. The ages of intervention appear to have no significant influence on MLU, TUA or PNV, although correlations between the ages of intervention and MLU are in the anticipated direction – that is, lower age of intervention was equated with higher scores on this measure. However these were non-significant. **Figures 5.13 to 5.15** illustrate mlu, tua and pnv (respectively) plotted against age at referral as an example of these relationships.

It should also be noted that the ages of intervention are also highly significantly correlated with one another ($p < .001$), with age of referral and age of first appointment correlating most highly ($r = .99$). This suggests that these two measures probably differ from each other by some constant value for all subjects.

This pattern of correlation between the ages of intervention poses the question of **collinearity**. It has been suggested that high levels of collinearity can affect the stability of regressional analyses and derived equations (Shevlin, 1996); this is noted and discussed in more detail later. None of the ages of intervention, however, were significantly correlated with hearing severity or, surprisingly, with age. **Table 5.3b** presents the correlations between age, age at detection, referral, first appointment and hearing-aid fitting, and between these ages of intervention and hearing level (better ear average).

Table 5.3b – Bivariate correlations between age, ages of intervention (age at detection, referral, first appointment, HA fitting) and hearing level. Correlations between ages of intervention and age are not significant, as are the correlations between age of intervention and hearing level. There is, however, a high degree of co-variance between age at detection, referral, first appointment and hearing-aid fitting.

	Hearing Level	Age	HA Fit	First App	Referral
Detection	-.35	.30	.95*	.95*	.95*
Referral	-.34	.27	.89*	.99*	
First App	-.34	.31	.89*		
HA Fit	-.37	.24			
Age	.15				

* $p < .001$, d.f. = 16

In summary, age at interview was significantly positively correlated to all language measures derived for the children in the study. Age of intervention, represented by age at detection, referral, first appointment and hearing-aid fitting, was also significantly related to some of the language measures (WDPM, PQU, VOC). These correlations were negative, implying that as age of intervention decreases the scores for these measures increase.

5.3.4 Effects of Hearing Threshold Level

The children in the study had been fitted with hearing-aids for an average of 28 months – over two years. However, this period ranged from 5 months, for the second youngest child, to 57 months for the oldest child in the sample, both of whom also have severe hearing impairments. Only two children had been wearing hearing-aids for less than 10 months at the time of participation in the study.

There are several ways to investigate the effects of hearing threshold level and age of intervention on the language measures. In the first instance, partial correlations between the language scores and hearing severity were derived, controlling for age at interview. In the second instance, multiple regression enabled the consideration of the joint effects (of hearing severity and age of intervention) on the language measures.

The partial correlations between the language scores and hearing severity are presented in **Table 5.3a**, with hearing threshold level represented by the average of the better ear (BEA) (dB HL).

Hearing threshold level was found to be significantly correlated to only one of the language variables – the proportion of questions (PQU) ($r = .46$, $df = 12$, $p < .05$).

However, this correlation was positive and, as such, was not in the anticipated direction. The correlation implies that a higher degree of hearing loss results in higher outcome for the measure PQU(see Figure 5.17). Taking the two highest correlations of hearing threshold level, with PQU and MLU (r = .46 and .28 respectively), the sign of correlation is such that a higher degree of hearing impairment could be associated with better language scores. **Figures 5.16** and **5.17** illustrate MLU and PQU respectively as a function of hearing level.

No correlation was found between hearing threshold level and the ages of intervention. However, the joint effect of age of intervention and hearing threshold level can be examined using multiple regression to model the effects.

Table 5.4 – Partial regression coefficients/parameter estimates (standard errors) for the language measures, derived from the multiple regressions using the independent measures of age at interview, age at referral, and degree of hearing loss in the better ear.

	Age at:			
Language Metric	**Interview quadratic**	**Interview (10 months)**	**Referral (10 months)**	**Hearing (10 dB)**
MLU	–	0.38 (0.13)*	-0.10 (0.14)	0.08 (0.11)
TUA	–	1.35 (0.59)*	-0.75 (0.62)	-0.24 (0.50)
WPM	–	6.14 (1.11)**	-2.34 (1.16)*	-0.60 (0.94)
WDPM	–	6.52 (1.14)**	-3.04 (1.20)*	-0.43 (0.98)
PNV	–	-0.09 (0.03)**	-0.02 (0.03)	0.00 (0.03)
PQ	–	0.02 (0.004)**	-0.007 (0.004)*	0.004 (0.004)
VOC	-15.6 (6.6)	208.52 (7.21)**	-19.19 (11.4)*	0.45 (0.87)

*p < 0.05, N = 16, d.f. = 13, **p < 0.005, N = 16, d.f. = 13

These effects can be seen in the parameter estimates, derived from the multiple regressions, shown in **Table 5.4**. Here, because of the high degree of collinearity between the ages of intervention, the age of intervention was approximated by the age at referral only. The age parameters are given per 10 months and the hearing threshold level is given per 10 dB HL. For the vocabulary measure, a quadratic in age at interview gives the best fit and presented parameters are derived from this.

The age at interview has a large significant parameter estimate for all language measures. The age at referral always has the next most substantial effect using a coefficient of variation criterion. This parameter makes significant contribution to the words per minute (WPM), proportion of questions (PQU) and the vocabulary (VOC) measures (when a quadratic age at interview function was used for the latter). The hearing threshold level parameter was found to be always very small. For the PQU measure, where the mean/s.e. criterion was best and for which the highest partial correlation is shown in **Table 5.3a**, a shift of 70 dB is equivalent to only 10 months of age at interview. In other words, a 70 dB increase in hearing threshold would seem to have a similar effect on PQU as a 10 month increase in age.

In summary, hearing threshold level within this sample of children did not substantially affect the language measures, but age at referral did.

5.3.5 EFFECTS OF SOCIO-ECONOMIC FACTORS

The effects of some possibly confounding covariates were also looked at, the most important being the socio-economic group (SEG) to which the family of the child belonged. The major effect of SEG was found on the MLU measure, where children whose parents belonged to groups 1, 2 and 3 (professional, intermediate, and skilled/semi-skilled occupations) consistently produce MLUs greater than those of similar age with parents in occupational groups 4 and 5 (unskilled occupations and unemployed). Dividing subjects into two groups, group 1 = SEGs 1–3 (N = 8), group 2 = SEGs 4–5 (N = 8), **Figure 5.18** shows the mean MLU for each group. However, taking SEG into account by statistically controlling for its effect, did not alter the pattern of results found above between age, age of intervention, and hearing threshold level and the language measures (presented in Tables 5.3a and 5.4).

5.3.6 CONTROL DATA

At this stage, no control data was collected for normal-hearing children for comparison. Also normative data on the range of language variables used here are not available for children in the UK. However, because of its wide use, normative values for the MLU scores can be deduced from available literature. Therefore MLU scores for the children in our study were compared with a template of normative MLU values taken from data obtained by Wells (1985) in a large scale longitudinal study which looked at language development in pre-school children.

His template of mean MLUs was calculated from eighteen 90-second samples of spontaneous spoken language collected for a sample of normal-hearing children (N = 125). When plotted, most of the scores for the hearing-impaired children were found to fall between the mean and minus 2 standard deviations. However, as can be seen from **Figure 5.19**, many perform worse than the lower percentile values achieved by the normal children. There are several reasons why this might be the case, some due to obvious methodological differences and others possibly related to the children's hearing status in combination with other factors.

5.4 DISCUSSION

5.4.1 HEARING THRESHOLD LEVEL

The comparison of MLU scores suggests that, at this stage in language development, MLU for the hearing-impaired children was substantially below that of normal-hearing children. The anomaly with the results was that none of the language measures was apparently related to the severity of the children's hearing impairments over the mild to severe range. This contrasts with a number of findings which suggest that hearing threshold level accounts for a large proportion of the variance in hearing-impaired children's language performance (Musselman & Kilcaali-Iftar, 1996). Accordingly, it would appear that hearing threshold level, over this range and excluding profound hearing impairment, does not have a significant impact on the spoken language measures. It appears that other factors, or a combination of factors, may have a greater influence on outcomes for these children.

Some studies have similarly reported a lack of direct significant influence of degree of hearing impairment on expressive and receptive spoken language abilities for children in this age group (Geffner, 1987). This suggests that for a wide range of hearing levels there was no differential effect, at this stage, on the children's spoken language ability. There can be little doubt that, had data from children with profound hearing impairments been included and evaluated, the picture may have been somewhat altered. Nevertheless, one profoundly hearing-impaired child (JH) was retained in the sample whose measures were analysed. Despite this child having a profound hearing loss (98 dB HL), she performs better than many of her less severely impaired peers on several of the language measures (PQU, WPM) and attains the highest MLU score (4.3). This may reflect the compensatory effect of other variables which may influence spoken language development in these circumstances. JH is an only child whose family belonged to seg-1. In addition, it was noted that she was receiving private tuition and was regulary visited at home by a peripatetic teacher and speech therapist.

5.4.2 AGE OF INTERVENTION

Significant correlations were obtained between the measures of age of intervention (age at detection, referral, first appointment, and hearing aid fitting) and the children's performance on some of the language measures. This implies that detecting and aiding a child's hearing impairment early holds advantages for the future development of certain aspects of spoken language.

This agrees with White and White (1987) who found that hearing-impaired children of hearing parents, who had received intervention early (before 18 months of age) as opposed to late (after 18 months of age), performed consistently better on a range of receptive and expressive language tests. From the language measures looked at here, VOC, WPM/WDPM and PQU were the three measures upon which age of intervention (most especially age at referral) appears to exert the strongest influence. This suggests that children receiving early intervention for their hearing impairments have more diverse vocabularies and faster rates of discourse, i.e. they produce more words per minute in conversation and ask more questions than children who have received later intervention. According to the parameter estimates derived for the language measures from the multiple regressions (see Table 5.4b), a decrease of 10 months in the age at referral corresponds to an increase of nearly 3 words per minute (wdpm) and 20 words in vocabulary. For five children in the study-sample, their hearing-impairments were not detected until 30 months or later. The results suggest that delays of this length may correspond to a reduction of 9 words per minute or 60 vocabulary words.

The language measures used however only provide a peripheral analysis of some global features of the children's language, aspects of which could be investigated further. One option would be to look more specifically at the range of vocabulary used and questions produced by the children, as well as incorporating and implementing more stringently drawn linguistic definitions (during coding) for these syntactic elements of language.

There is some evidence to suggest that factors such as confirmation of the hearing-impairment, family adjustment and acceptance of the impairment may all play a positive role in enhancing outcomes for hearing-impaired children (Musselman and Kircaali-Iftar, 1996). This may in part account for why it seems to be age at referral that stands out in its effects on the chosen language metrics, rather than the other measures of age of intervention. It could be argued that with referral comes the first professional recognition and validation that a problem may exist and needs further investigation. Referral may serve to initiate a process that has been sought after and is welcomed by the family when it occurs. Indeed, in the majority of cases, the parents in this sample stipulated during the interview that they had suspected the presence of a hearing loss well before a referral was finally received (63%). Referral seemed to be viewed as a milestone in acknowledgement for their concerns. This may be a major turning point for parents in that they may begin to re-evaluate conceptions and misconceptions about hearing impairment, in anticipation of the possibility that their child is confirmed to be hearing-impaired.

5.4.3 Time between referral and hearing-aid fitting

The average length of time between referral and hearing-aid fitting for children in this study was one year (12 m). For some of the children (DA, JA and SB), including one child with an early detection and referral age of 4 and 9 months respectively, this period exceeded 20 months. Reasons for the discrepancy between age at referral and age at hearing-aid fitting are various.

The study failed to evaluate the appropriateness of aids received by the children or detail counselling which they and their families may have received. These constitute two factors that may predictably have influenced outcomes for these children. As can be seen from the data, delays in hearing-aid fitting did occur and these may have occured for a variety of reasons. Difficulties leading to delays between referral and hearing-aid fitting include those related to diagnosis and the child's hearing impairment per se, and those related to the child's family. In the former category, these include difficulties in confirming diagnoses in very young infants. Even with the availability of techniques such as visual-reinforcement audiometry this can at times prove difficult. In addition, these children would have been initially tested in the mid-1980s since which time indubitable progress has been made in the assessment of hearing impairment in very young infants (using ABR for example). Other problems in this category include the presence of middle ear complications requiring surgical intervention, or children's difficulties tolerating or accepting hearing-aids. In the latter category (difficulties related to the family) factors such as lack of attendance and missed clinic appointments by the family can exacerbate delays. In some cases, familial non-acceptance or denial of the diagnosis, as well as family grief and anxiety may constitute some of the causes of delayed intervention.

As a result, attempts to address the question of early intervention were complicated by these factors. For a variety of reasons, only three subjects in this study were found to have been fitted with hearing aids before 12 months of age. Two of these had profound hearing impairments and were excluded from the analyses due to insufficient verbal interaction for scoring purposes.

At present there generally remains a strong negative correlation between early intervention and degree of hearing impairment. The proportion of hearing-impaired children (in particular with mild-to-moderate hearing impairments), without multiple handicaps, detected within the first year of life is still small. A complexity in the composition of the subject sample, additional to the difficulty of finding enough subjects receiving early (for the purposes of this study – before 18 months of age) intervention, is a possible confounding variable.

Additionally, many of the children referred late (after 18 months) for investigation of possible hearing impairment may have been referred because of notably poor development of spoken language, even though this may not have been explicitly recorded as a reason for referral. A selection bias on the dependent rather than the independent variable might then occur. This possibility is supported by evidence from Gilbertson & Kamhi (1995) who suggest that a subset of children with mild-to-moderate hearing impairments may have language impairment independent of their hearing loss.

Alternatively, there may be other factors, not necessarily represented by the variables selected, which serve to precipitate referral and diagnosis of a child's hearing impairment when few other indicators are present. This might particularly be the case for some children with mild-to-moderate hearing impairment identified early. These may include parental awareness of hearing services available, knowledge of other children with hearing problems, or heightened sensitivity to the child's needs.

It is hoped that some of these complexities may change as more of those children suffering solely from mild-to-moderate (and severe) hearing impairments come to be detected early (at least within one year) as a result of improved neonatal screening procedures. Therefore the possible benefits of fitting these children with hearing aids before they have reached 12 months of age, and earlier, need to be evaluated.

5.4.4 MLU AND LANGUAGE MEASURES

Regarding MLU, an age boundary of 4 years is often stipulated by investigators (Brown, 1973; Miller and Chapman, 1981; Wells, 1985) as the limit past which this measure reaches an asymptote and becomes unreliable. Despite being a less reliable indicator of syntactic ability for the older children in this study, it would nevertheless be reasonable to expect MLU scores for these children to fall around the peak of the asymptotic mean at 48 months. Many of the MLU scores, in comparison to Wells' template, were well below the mean in the data obtained for the older children in the sample and provides perhaps a useful indication of the delay in language performance reported informally and in comparative studies of language emergence in hearing versus hearing-impaired children (White and White, 1987; Stokes and Bamford, 1990).

One major short-coming of the language measures used in this study was their derivation from language transcripts not controlled for the number of utterances. For each child, the period of interaction transcribed was standardised so that transcriptions were made of 30 minutes of interaction for each child. As a result, some language measures (particularly those related to rate of speaking) may more accurately reflect some aspect of the interaction context (e.g. type of play, mothers' rate of speaking) than the children's general talkativeness or communicative competence in this area.

Socio-economic grouping was found to be an important predictor of MLU score, but this relationship has to be viewed cautiously. Although this would suggest that the role of the family and home environment may account for a proportion of the variance, SEG itself remains difficult to measure definitively and other investigators have highlighted the difficulties in drawing conclusions from observed relationships between SEG and language performance (Wells, 1985). It may be that a number of other factors are mediated by SEG; so that the influence of SEG on MLU is representative of a combined effect of other factors, such as better access to services, earlier intervention, or more parental time available to support habilitation. In addition, SEG influences may be more accurately represented by a compound value derived from the consideration of a variety of factors (e.g. parental occupation, parental education, size of family).

The results from this initial study relate expressive language in hearing-impaired children, not to the severity of their hearing-impairments, but to the age of intervention. However, a number of further factors may have contributed to the children's scores on the language measures. For instance, the subjects differed in the amount of exposure they had to rehabilitative educational programmes, peripatetic teachers of the deaf or speech therapy, some having received none at the time of interview and others having received some form of regular supplementary help. Unfortunately it proved difficult to quantify these variables for this group of children, thus formal analysis of their contribution to outcomes is very difficult to surmise. Intervention variables such as these would be expected to exert some influence on the children's language abilities and thus need to be specifically taken into account in consideration of their interactive and compound effects. Other studies have recognised that 'age of intervention' incorporates a variety of 'several related events' (Geffner, 1987). Here, we concentrated on four events – the age at detection, referral, first appointment and hearing-aid fitting. In addition, White and White (1987) in their study looking at the effects of age of intervention on language (described earlier) identified 'age of onset of training of residual hearing', 'age of utilisation of hearing aids', 'age of involvement of family' and 'age of entry into a programme' as factors combining to epitomise the 'compound concept' of age of intervention. While many of these variables will inevitably be collinear, others may be considered as possibly separable contributory factors.

5.4.5 HEARING-AID USE

Although mothers were asked about their child's hearing-aid use, it was difficult to independently ascertain how consistently each child was wearing his/her hearing aids. Despite the fact that they were assured otherwise, it is possible that the parents perceived the interviewer to be affiliated to the Children's Hearing Services and thus failed to accurately represent patterns of hearing-aid use in cases where children may have been failing to use their hearing-aids regularly.

Another potential influencing factor on results was the child's operational hearing threshold level at the time of the visit. The interviewer made a note of any overt symptoms of illness during the visit, and in no cases were any symptoms noticed. However, no assessment of aided hearing threshold level was made on the day of the session. This may be of importance, particularly in light of the cross-sectional design of the study. On the day of the interview, the presence of a cold or transient ear infection could have further reduced functional hearing and this may have affected recorded outcomes. It was anticipated that the use of an Automated Toy Discrimination Test (Ousey et al, 1990) for measuring hearing thresholds for speech sounds would be available in the next study to rectify this.

5.4.6 SOME LIMITATIONS OF THE STUDY

The presence of other siblings and/or other adults during recording may have also have affected the observations of mother-child interaction on the day of the interview. Certainly, it has been suggested that the language directed to a child (by a parent) differs in the presence of a sibling from that observed in the absence of any siblings (ref.). This is an area that future investigations could control for by specifying that each child be seen in the presence of the mother only. This stipulation however may place the participants in an unusual situation. It may be that, for some children, interaction in a 'naturalistic setting' consists of the presence of other siblings and family members.

Finally, the grouping of subjects in this study was necessary to explore relationships between the variables of interest. Subject grouping also enables factors to be highlighted which due to the individual variation may not have emerged. However, one disadvantage of this approach is that it serves to obscure individual differences which constitute an important factor influencing language performance. (Individual cases can be looked at in more depth for the purpose of exemplifying potential issues and this is considered in Chapter Eight). Related to this is the ascertainment of IQ scores for the children. IQ has been postulated as an important factor in language performance and development (Levitt 1987). However, a consideration of the range of Intelligence tests which could be used with this age range of children led to the decision not to incorporate IQ measurements. It is recognised that this may be considered an important omission from the study. However, many Intelligence tests are biased in that they are mediated by verbal language, and none have been standardised for hearing-impaired populations. Non-verbal subtests (WISC-R) were examined and these were also deemed inappropriate for use at the time of the study. Even non-verbal IQ tests demand some level of verbal language comprehension from participants, thus it could not be assumed prior to the study that some children, as a result of their hearing difficulties, would not be disadvantaged when performing the tests. In addition, there was concern that the process of attempting to conduct additional tests during the session may only serve to cause those children with poor language abilities and their families a degree of unnecessary distress.

5.5 CHAPTER SUMMARY

This study demonstrates that the observational language procedure and analyses employed reflect expressive spoken language in a heterogeneous group of hearing-impaired children. While language measures were found to be highly correlated to age, the results suggest that the potentially negative effects of hearing severity may be ameliorated by factors such as the age of intervention. The results suggest that even children with milder hearing loss may suffer detrimental effects in their development of spoken language if intervention is long delayed.

In this study, it was the age at referral that appeared to exert the strongest influence on language performance, with earlier referral corresponding to better language outcomes. This relationship has been postulated by some of the few studies that have investigated the effects of milder, fluctuating conductive hearing losses on speech and language development (Klien and Rapin, 1988; Menyuk, 1986). Similarly, studies looking at specific language impairment in children suggest that early identification may hold benefits for future language production and comprehension skills (Stothard, 1996).

Limitations of this study indicate that more detailed investigations are needed on the spoken language abilities of children with mild-to-severe hearing impairments. Comparison with normal hearing children of similar age and background may also be useful and a consideration of a number of other factors which may relate to age of intervention, such as frequency of rehabilitative tuition, is essential. Investigation of the language addressed to the child by the mother during interaction may also be found to play a role in observed outcomes.

The cross-validation of findings is an important feature of empirical work. Thus a second study, aiming to replicate these findings and address some of its shortcomings was conducted. This is presented in Chapter Seven.

Chapter Six presents the questionnaire responses and the attitudes of parents to the services provided.

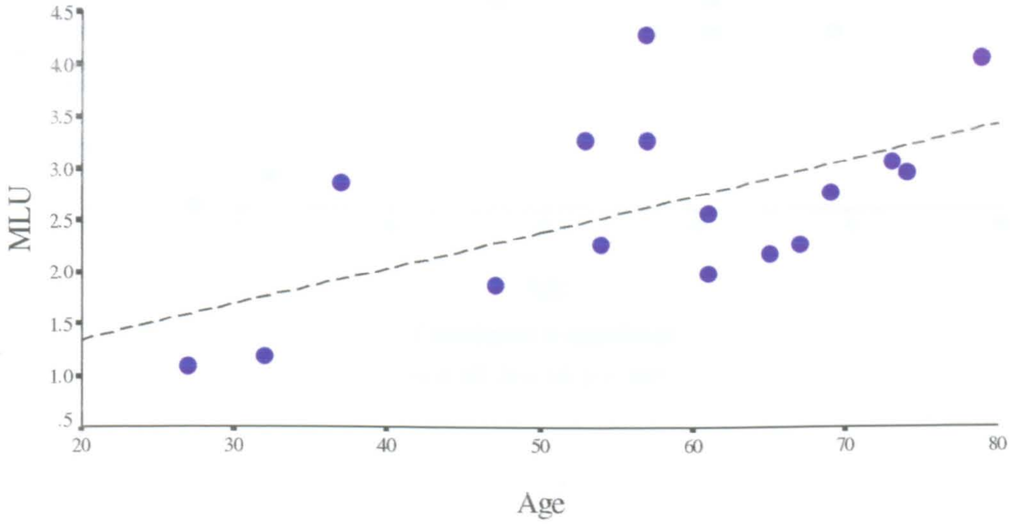
CHAPTER FIVE FIGURES

In Figures 5.1 to 5.7, a linear relationship between the language measures and age can be seen, such that older children tend to produce higher scores on the language variables.

Figure 5.1

Mean Length of Utterance as a function of Age (in months)

(STUDY 1)



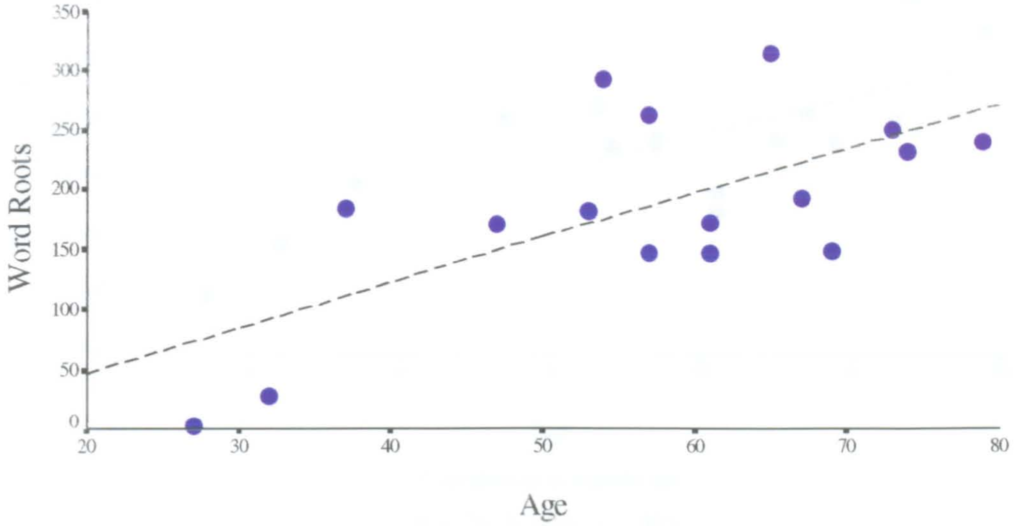
Correlation is significant

(r = .60, N = 16, p < .05)

Figure 5.2

Number of Different Word Roots as a function of Age (months)

(STUDY 1)



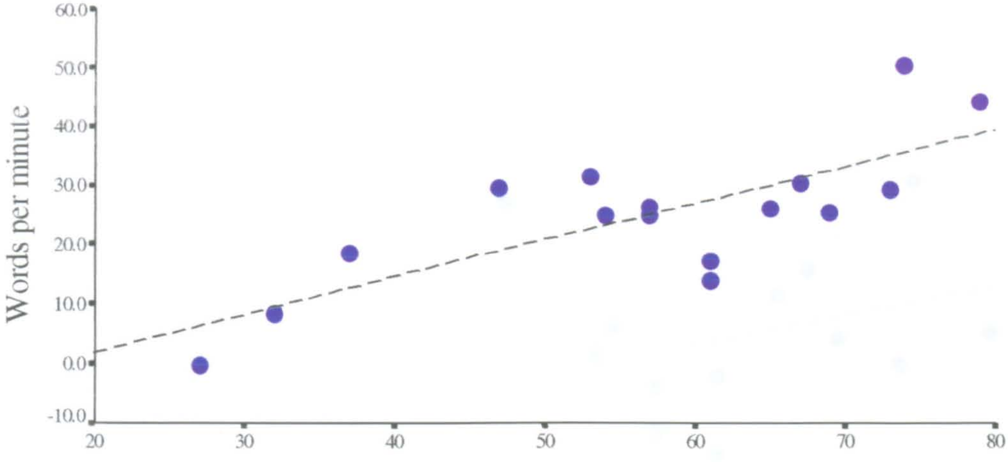
Correlation is significant

(r = .67, N = 16, p < .005)

Figure 5.3

Words per Minute (WDPM) as a function of Age (months)

(STUDY 1)



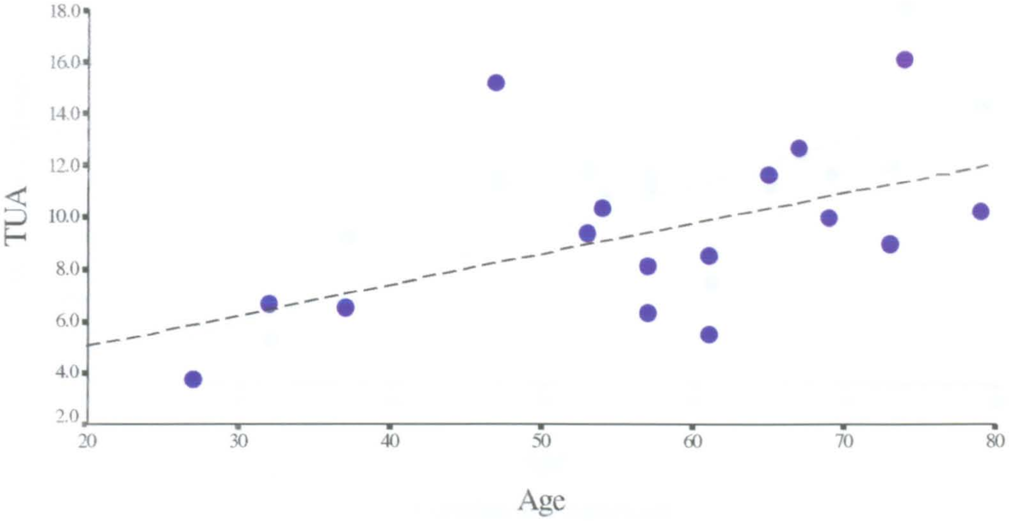
Correlation is significant

($r = .76$, $N = 16$, $p < .005$)

Figure 5.4

Total Utterance Attempts per Minute as a function of Age (months)

(STUDY 1)



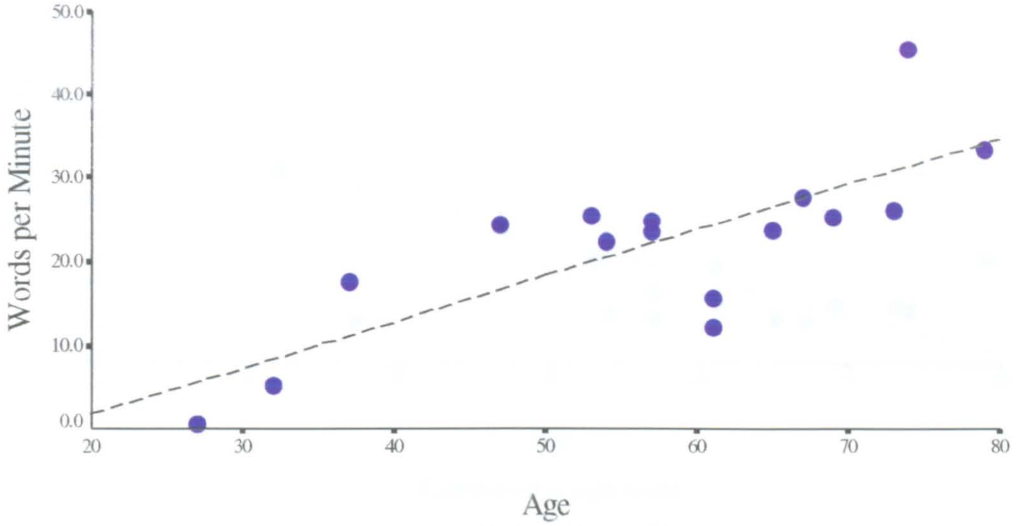
Correlation is significant

(r = .53, N = 16, p < .05)

Figure 5.5

Words per Minute (WPM) as a function of Age (months)

(STUDY 1)

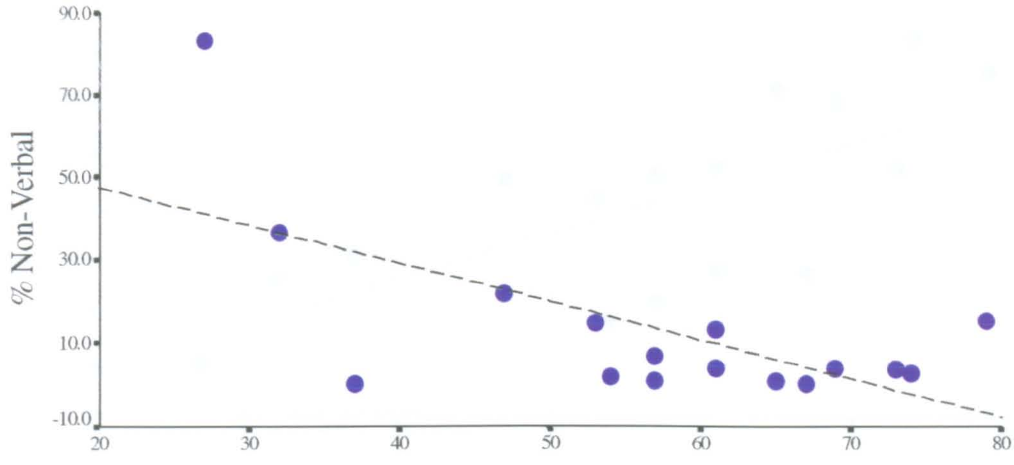


Correlation is significant

(r = .78, N = 16, p < .005)

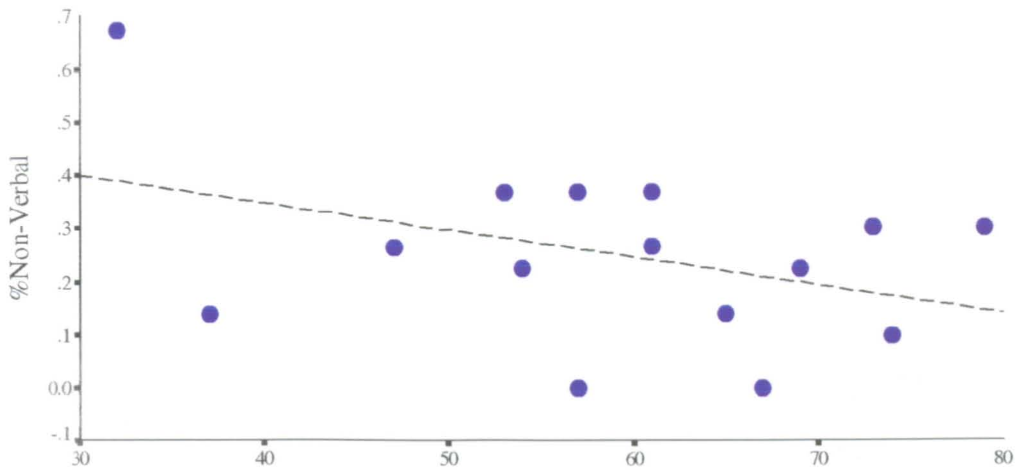
Figure 5.6

Proportion of Non-Verbal Utterances as a function of Age (months)
(STUDY 1)



Correlation is significant
(r = -.66, N = 16, p < .01)

Proportion of Non-Verbal Utterances (arcsin root transformation) as a function of Age

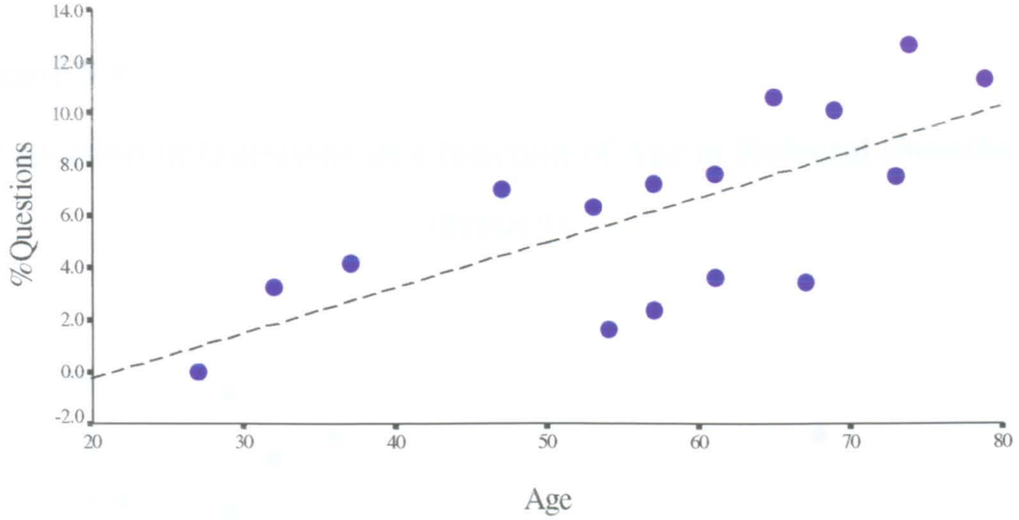


Correlation is significant
(r = -.57, N = 16, p < .01)

Figure 5.7

Proportion of Questions as a function of Age (months)

(STUDY 1)



Correlation is significant

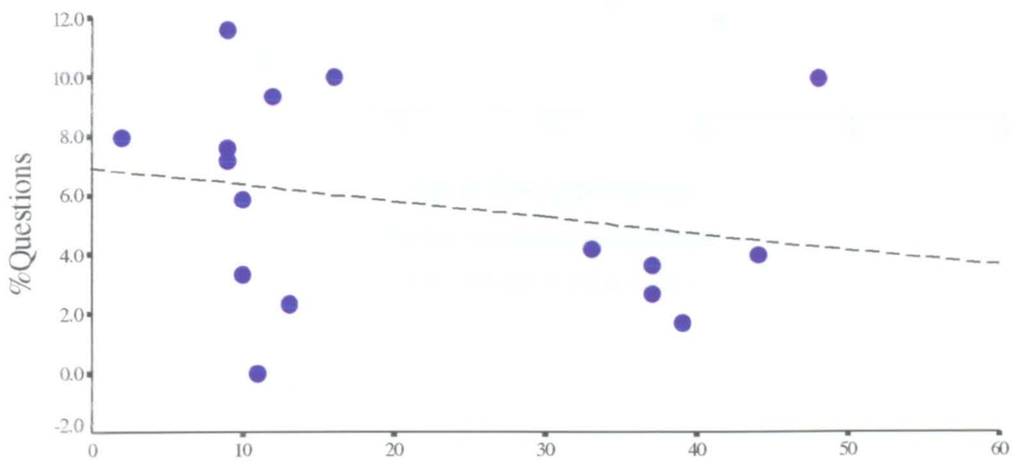
($r = .71$, $N = 16$, $p < .005$)

Figures 5.8 to 5.11 illustrate the relationship between two of the language measures (PQU and WDPM) and the age of intervention variables – age at referral, first appointment and hearing-aid fitting. Both of the language measures can be seen to be negatively related to age of intervention, such that lower scores appear to be associated with later intervention. All correlations were significant, controlling for the age of the child at the time of recording. These relationships are presented in bar chart form in Figure 5.12 for easier comparison.

Figure 5.8

Proportion of Questions as a function of Age at Referral (months)

(STUDY 1)



Age at Referral

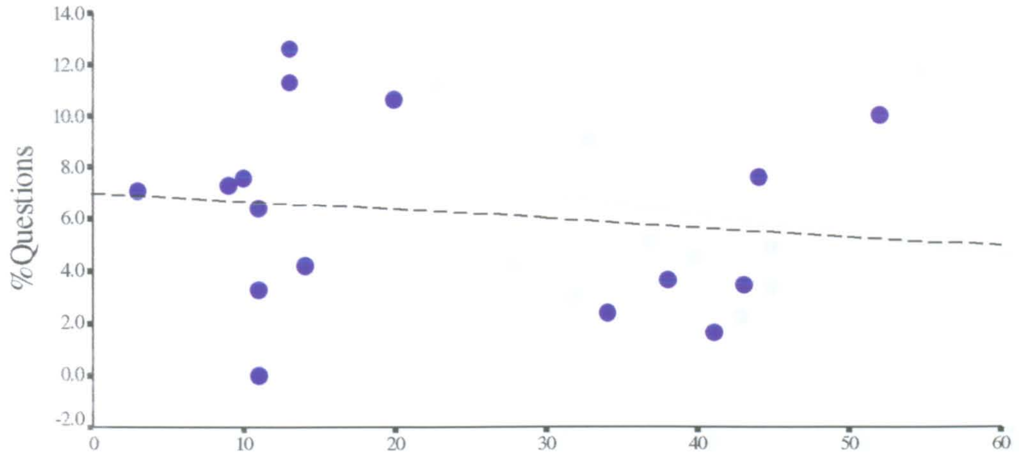
Partial correlation is significant

($r = -.54$, d.f. = 13, $p < .05$)

Figure 5.9

Proportion of Questions
as a function of Age at First Appointment (months)

(STUDY 1)



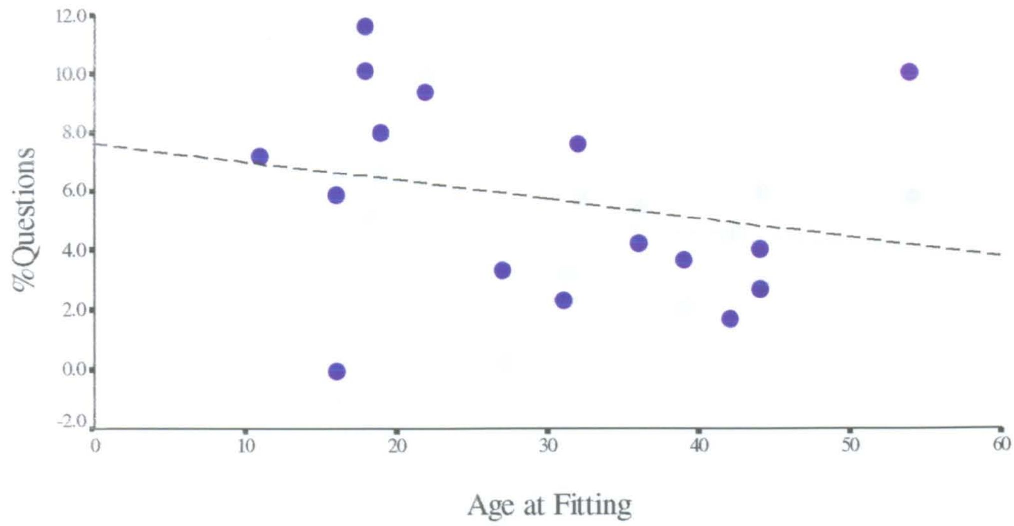
Partial correlation is significant

($r = -.53$, d.f. = 13, $p < .05$)

Figure 5.10

Proportion of Questions as a function of Age at Hearing-Aid Fitting (months)

(STUDY 1)



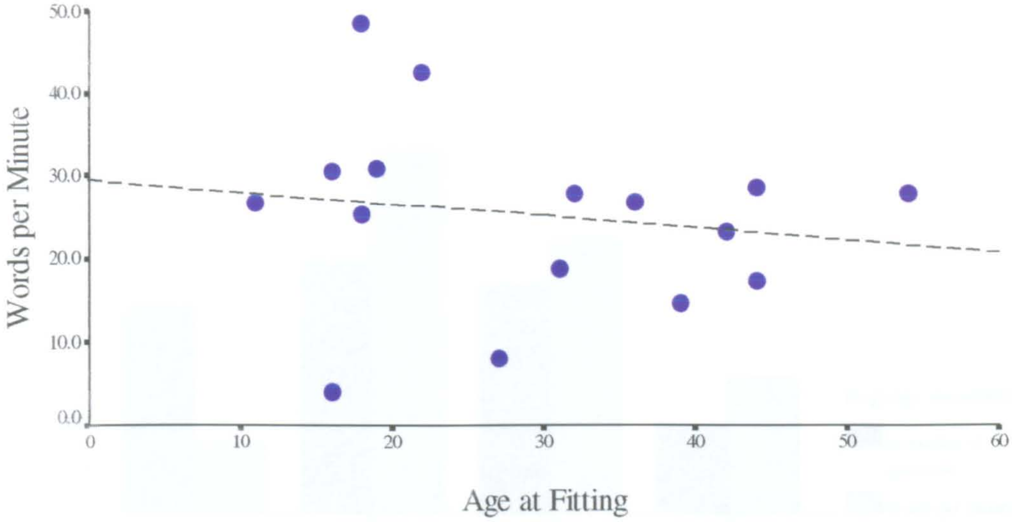
Partial correlation is significant

($r = -.51$, d.f. = 13, $p < .05$)

Figure 5.11

Words per Minute (Wdpm) as a function of Age at Hearing-Aid Fitting

(STUDY 1)



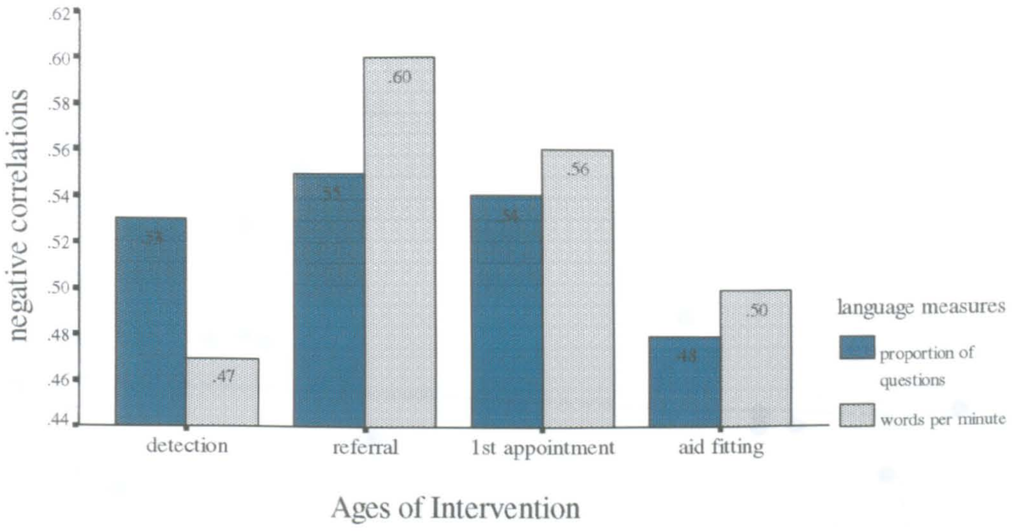
Correlation is significant

($r = -.54$, $df = 13$, $p < .05$)

Figure 5.12

Partial Correlations between Age of Intervention and Two Spoken Language Measures (PQU and WDPM)

(STUDY 1)

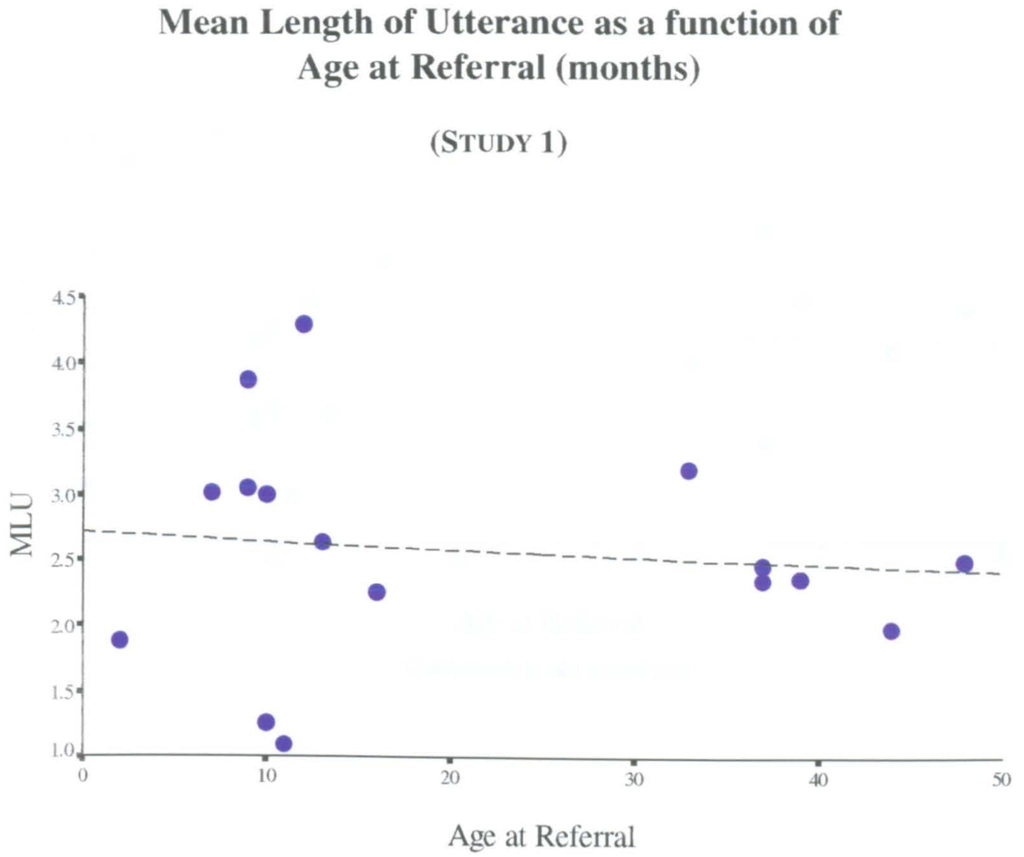


All partial correlations are significant

(p<.01, d.f.=13)

Figures 5.13 to 5.15 illustrate that not all of the language measures were found to be significantly related to age of intervention. Age of intervention is represented by age at referral.

Figure 5.13

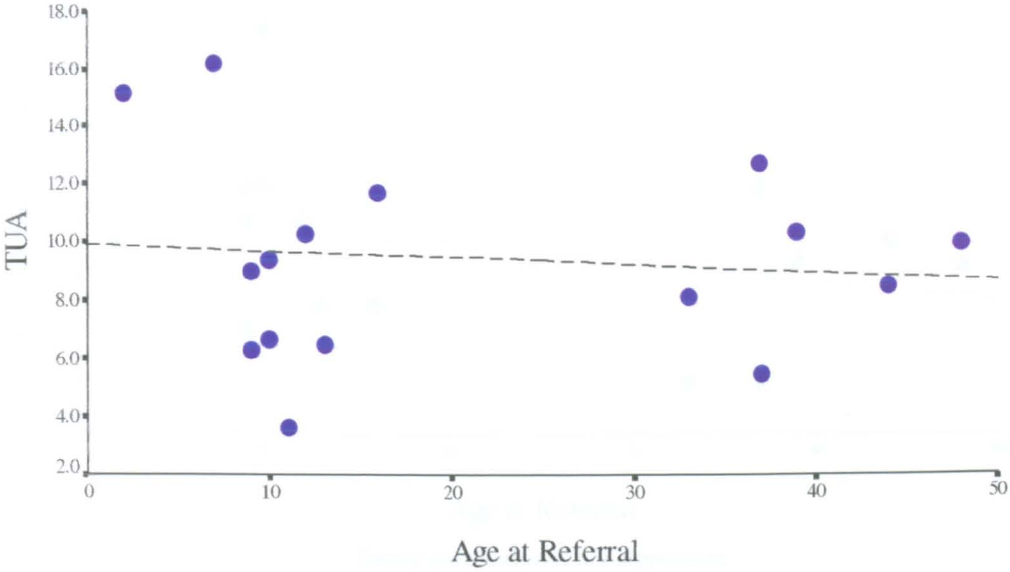


Partial correlation is not significant

Figure 5.14

Total Utterance Attempts as a function of Age at Referral (months)

(STUDY 1)

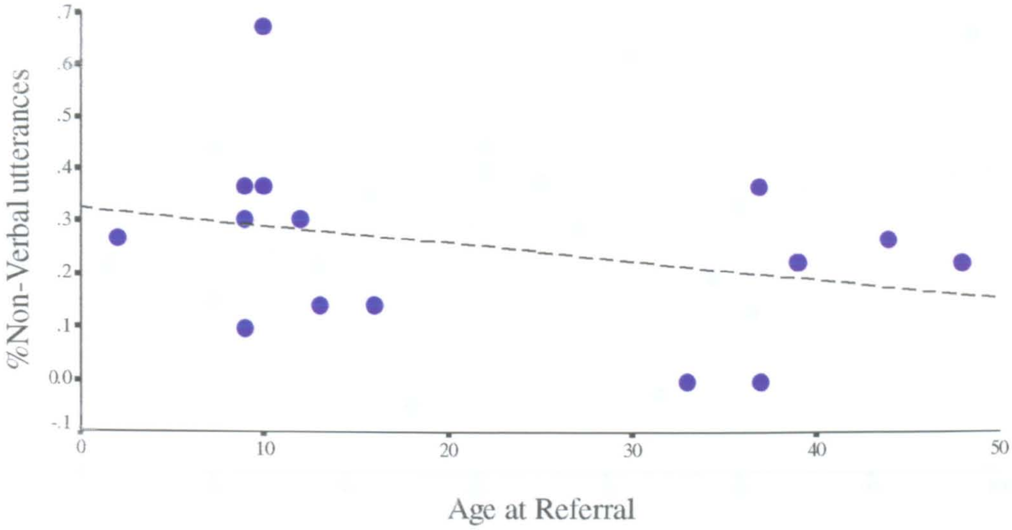


Correlation is not significant

Figure 5.15

Proportion of Non-Verbal Utterances as a function of Age at Referral (months)

(STUDY 1)



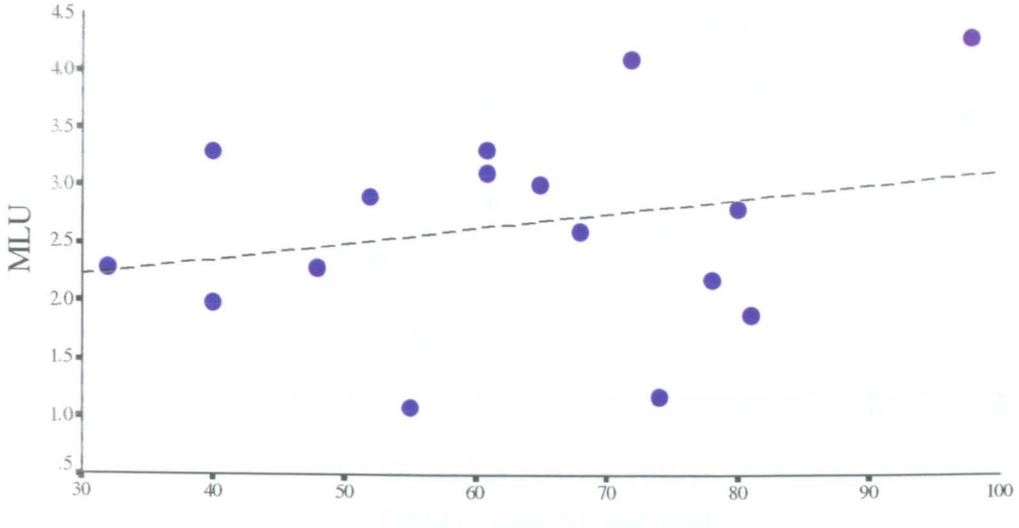
Partial correlation is not significant
(r = -.25, d.f. = 13)

The arcsin root transformation of PNV is presented.

Figure 5.16

Mean Length of Utterance as a function of Hearing Level (BEA)

(STUDY 1)



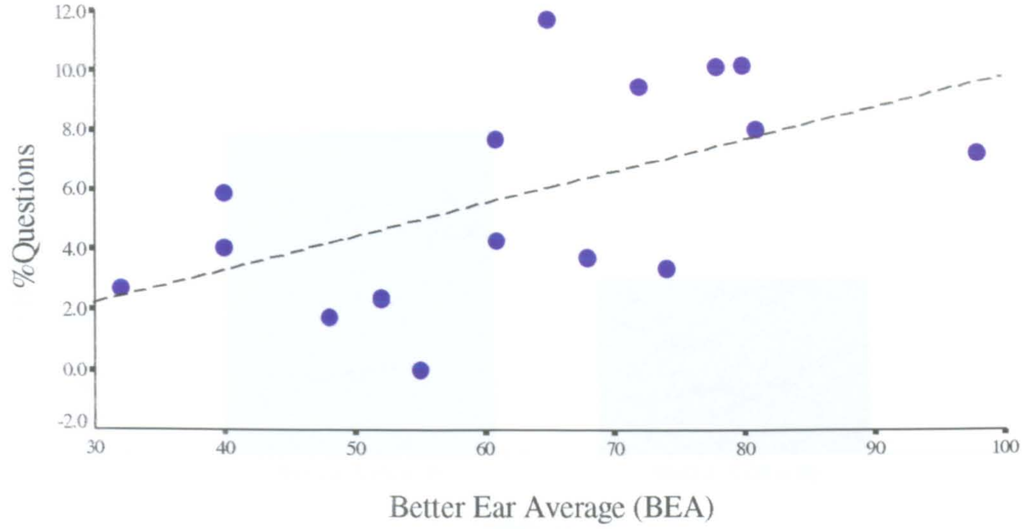
Partial correlation is not significant

The graph indicates some relationship between MLU and hearing severity level (BEA) and would suggest that as hearing level increases, the MLU increases. However, the correlation, controlling for age, was not found to be significant.

Figure 5.17

Proportion of Questions as a function of Hearing Level (BEA)

(STUDY 1)

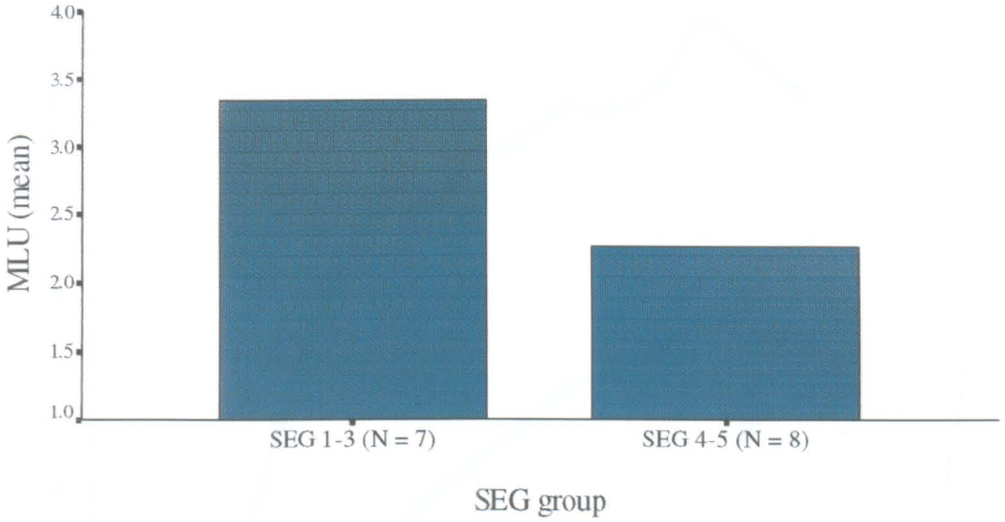


Partial correlation is significant

($r = -.46$, d.f. = 13, $p < .05$)

Figure 5.18

Mean Length of Utterance by SEG Group
(STUDY 1)

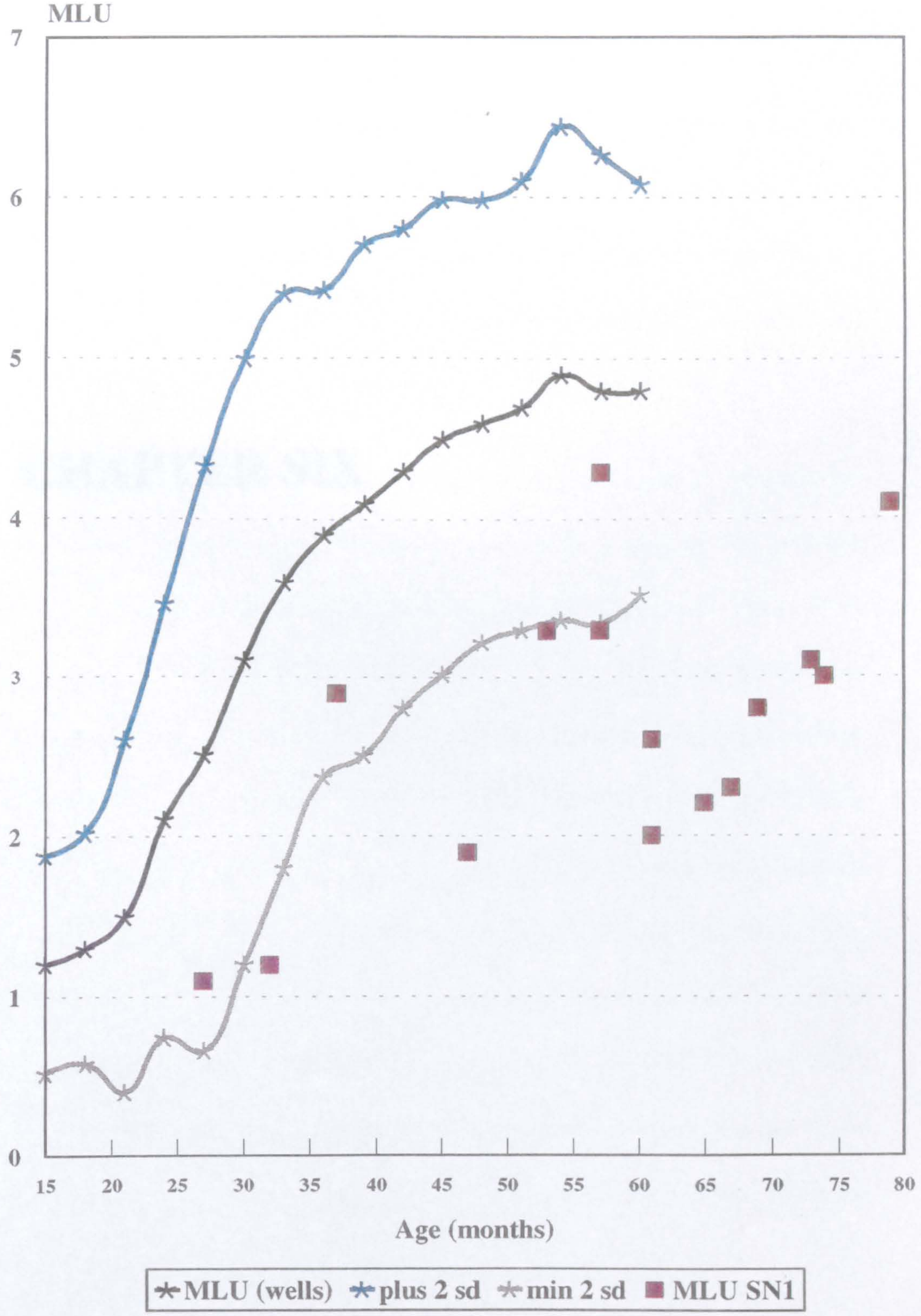


Difference between groups is statistically significant

($p < .005$)

Figure 5.19:

MLU data for hearing-impaired (SN) children plotted on template of MLU from Wells (1985)



CHAPTER SIX

CHAPTER SIX

6.1 PARENTAL ATTITUDES

6.1.1 INTRODUCTION

Parental views, anxieties and attitudes towards their children's hearing-impairments may play an important role in modifying the potentially detrimental outcomes commonly associated with hearing loss. The questions which parents were asked during the interview stage of the studies conducted, aimed to provide an overview of how parents in these samples felt about issues related to the detection and management of their child's hearing impairment.

The detection of a child's hearing-impairment has enormous potential consequences for the parents/family of the child. Therefore, family-centred services that take into consideration families' needs for information and support may be important. These would recognise that the parents of newly identified hearing-impaired children may require guidance relating to the management of their child's hearing impairment, education/information which they can refer to outside of the clinic, and counselling to come to terms with negative emotions that may arise. As the majority of hearing-impaired children are born into hearing families, it can reasonably be assumed that parents may have limited knowledge or experience in relation to hearing-impairment prior to their child's diagnosis. This lack of information and experience, coupled with often erroneous perceptions about deafness, can exacerbate fears, prolong stress and anxiety, and potentially influence the support that the child may receive within the family unit.

Few studies have specifically considered the impact of detection and diagnosis for hearing-impairment on the parents and family, or evaluated parental attitudes towards the processes involved and services and support provided. If a broader definition of intervention is to be recognised, parental attitude forms an important factor that may influence outcomes for the child.

Of the few surveys which have been conducted on parental attitudes to detection and diagnosis, wide support has been reported for earlier identification of hearing-impairment in children (NDCS, 1990). If this is to be achieved for *all* hearing-impaired children, not just those with profound hearing-impairments, the provision of support and habilitation for those involved would need careful evaluating. This would need to include health professionals, who may need specific training in interpersonal communication and the conveyance of sensitive information to the public.

6.1.2 PROCEDURE

During the home visits, the parents of hearing-impaired children were asked a series of questions. The questionnaires used varied slightly in studies one and two, but both asked about the detection and diagnosis of hearing impairment and the services provided. The qualitative findings – parental responses – from both studies are presented in this chapter. As will be shown, a number of overlapping issues were raised.

The main categories of questions that study one parents were asked are outlined below: a more complete list of questions is presented in the Appendix.

Table 6.1 Outline of questionnaire

Background Information
Detection and Diagnosis
Aetiology
Feelings towards Diagnosis
Services Provided

In the second study, the section on the aetiology of the child's impairment was expanded to include questions about the child's general health. In addition, a section of questions relating to language and communication was incorporated. A more complete list of questions is presented in the Appendix.

Eighteen parents of hearing-impaired children were interviewed from study one, and sixteen from study two (total number of participants = 34). An interview format was used and all responses were audio and video-taped. Responses to questions were coded according to a set of closed response categories, where appropriate. However, parents were given the freedom to respond to questions as they wished. Thus, they often elaborated, providing full and detailed responses to many of the questions asked. The advantage of categorising responses on a closed set of categories is that responses were able to be grouped and patterns of response amongst the parents compared. The disadvantage is that it is difficult to do full justice to the richness and detail of the responses provided. However, as parental responses often touched on very personal and emotionally sensitive issues, this may have been appropriate. The presentation of responses from the questionnaires in this chapter is selective and addresses those areas which directly relate to detection, diagnosis and the services provided.

The questions aimed to explore some of the parent's initial feelings following the detection and diagnosis of their child's hearing impairment, as well as their attitude towards the services that were provided at that time. The responses have been grouped for presentation below and individual comments are reported as exemplars.

6.2 Confirmation of Hearing Impairment

6.2.1 Detection

Four children overall – three children in the first study and one in the second – had been screened for hearing-impairment after birth and in two of these cases had been given a false negative result. All four children received a neonatal screen because they were on the at-risk register as a consequence of prematurity (N = 2) and neonatal intensive care (N = 2).

6.2.2 Initial Suspicion

When did you first suspect that your child might have a hearing-impairment?

Study one parents (N = 18):

AGE OF CHILD WHEN SUSPECTED OF HAVING HEARING IMPAIRMENT	PERCENT (N)
soon after birth	17% (3)
less than 6 months	17% (3)
between 6 and 12 months	28% (5)
between 12 and 18 months	11% (2)
after 18 months	28% (5)

Study two parents (N = 16):

AGE OF CHILD WHEN SUSPECTED OF HAVING HEARING IMPAIRMENT	PERCENT (N)
soon after birth	0
less than 6 months	19% (3)
between 6 and 12 months	31% (5)
between 12 and 18 months	19% (3)
after 18 months	31% (5)

The modal ages at which children were suspected to have hearing impairments were between 6 and 12 months and after 18 months for both sets of parents. The number of detections between 6 and 12 months probably relates to the health visitor screen, which usually took place at between 6 and 8 months. The later age period for detection possibly corresponds to periods in the child's development where parents may have begun to notice atypical markers in development (e.g. delayed language, social behaviour). This may have prompted parental or professional concern. There is some evidence from parents' responses for these relationships.

A number of parents, who had suspected that their child was hearing-impaired early on in the child's development, reported that they had decided to wait for the health visitor screen, knowing that one was imminent. The following outlined sequence of events described by one parent illustrates this.

The mother suspected that the child had a hearing loss but waited for a hearing test from the health visitor, which she believed would be imminent. When the child was 20 months old, a test still had not been received. The mother requested a test at a local clinic, which the child passed. However, the mother was still concerned. When the child started nursery, she experienced problems with the nursery teacher who felt that the child was deliberately ignoring her. This prompted the mother to seek another hearing test, which was conducted at the local clinic and which the child also passed. It was only when a new health visitor informed the mother that she could approach the Children's Hearing Assessment Centre directly, that the child was eventually assessed and diagnosed with a moderate hearing loss at the age of three.

This mother commented:

> *"I wish that she could have had her hearing test at 7 months. I didn't know she could go anytime and was waiting for a form to come through"*.

The mother felt that, had she known that she could have requested a referral to have her child's hearing properly assessed, she would have done so. A great deal of regret for "lost time" was expressed. Over half the parents in the second study similarly conveyed that they thought their child should have been referred much earlier for a hearing assessment. Fewer, however, expressed the feeling that their initial suspicions were ignored by professionals.

Prompt referral seems to have been a particular issue for parents with first born children. In these instances, parents said that their lack of experience did not enable them to determine that their child was not vocalising as normal. They had no model for comparison. This encouraged them to ignore their own suspicions.

Another parent reported that, despite suspecting that her child had a hearing-impairment soon after she was born, she and her husband decided to wait for the 6–

eight-month health visitor assessment, which they knew would include a hearing test.

> *"We were waiting for the 6 month hearing check, which didn't materialise".*

As a result, there was a further delay of several months before the child was eventually referred, as a result of parental pressure, to CHAC for assessment. This child was subsequently found to have a profound hearing-impairment, which was diagnosed after the first year.

Even in instances where the health visitor assessment did occur on time, some parents were informed that their child's hearing appeared to be normal. This resulted in further delays and made it difficult for them to get the referral they felt was necessary as the following examples illustrate:

> *"The health visitor said there was nothing wrong with him" (7 month test)*

This study-one parent pushed for a referral which she received at 9 months for the child. This child was subsequently diagnosed with profound hearing-impairment.

> *"I was not happy that I had to ring up to get her tested in the first place because she had been missed"*

This study-two parent said that she had to take responsibility for having her child referred as the health visitor had passed the child unconvincingly.

In six (33%) cases in study one and four cases in study two (25%), children were initially given false negative results following an initial hearing assessment performed by a health visitor or a local clinic, before being assessed by CHAC and appropriately diagnosed. One mother commented:

"I feel that if the clinic had done its job correctly in the first place she would have been referred earlier"

6.2.3 REFERRAL

When was your child referred?

Study one parents:

AGE OF CHILD WHEN REFERRED	PERCENT (N)
less than 6 months	11% (2)
between 6 and 12 months	44% (8)
between 12 and 18 months	11% (2)
after 18 months	33% (6)

Study two parents:

AGE OF CHILD WHEN REFERRED	PERCENT (N)
less than 6 months	6% (1)
between 6 and 12 months	38% (6)
between 12 and 18 months	25% (4)
after 18 months	25% (4)

Referral took place for most children within the same time categories identified for initial detection – (study one) 44% of children were referred between 6 and 12 months and 33% after 18 months, (study two) 38% between 6 and 12 months and slightly fewer after 18 months.

The majority of referrals occurred via the health visitor in both studies, for reasons which have been highlighted above – all children would have been assessed at around 6 – 8 months as part of a routine health visitor check. Health visitor referrals accounted for 72% (study one) and 56% (study two) of referrals, with the remainder being made via the family's GP, paediatrics or by the parents themselves approaching CHAC directly. In the second study a wider variety of methods of referral were apparent, with slightly more parents making direct referrals to CHAC or via their GPs. This may be indicative of an improvement in parental awareness about referral options following initial suspicion of hearing impairment in a child.

6.2.4 DIAGNOSIS

For this particular sample of families, the majority of parents reported that their children's hearing-impairments had been diagnosed after 18 months of age (44%). 27% reported that their children were diagnosed between 6 and 12 months (study two – 19%) and only one child from each study was reported to have been diagnosed before 6 months of age. A noticeable difference in responses from study one and study two participants related to the role of speech and language in prompting diagnosis and initial suspicion. Four parents in the second study specifically mentioned that speech and language delay had been a key factor in prompting concern about their child's hearing. All four of these children were diagnosed after 18 months of age. No study one parents made any reference to speech and language delay in a similar way. Both were asked identical questions (see DD6 in the Appendix).

When was your child's problem first diagnosed?

Study one parents:

AGE OF CHILD WHEN DIAGNOSED	PERCENT (N)
soon after birth	0
less than 6 months	6% (1)
between 6 and 12 months	28% (5)
between 12 and 18 months	22% (4)
after 18 months	44% (8)

Study two parents:

AGE OF CHILD WHEN DIAGNOSED	PERCENT (N)
soon after birth	0
less than 6 months	6% (1)
between 6 and 12 months	19% (3)
between 12 and 18 months	31% (5)
after 18 months	44% (7)

6.2.5 FEELINGS TOWARDS DIAGNOSIS

Twelve study one parents (67%) and ten study two parents (63%) reported feeling upset, shocked and depressed upon their child's hearing-impairment being diagnosed. One parent described herself as being "completely devastated" by the diagnosis. Parents talked about crying for days after the diagnosis and imagining the worse for their child. This is indicative of an area where information may be usefully provided to prevent misconceptions exacerbating negative feelings towards a diagnosis of hearing impairment. Two families also reported that extended-family members – grandparents of the child – refused to accept the diagnosis, which seemed to be a cause of ongoing argument and strain.

Expressions of anxiety and stress are difficult to clearly interpret. In some cases, the feelings towards diagnosis may have been confounded by the increased level of stress and anxiety that quite often follows the birth of a child, particularly for new parents. For instance, in the case of one parent with two hearing-impaired children, while her response to the diagnosis of the first was one of devastation, she reported feeling "accepting" of the diagnosis for her second child.

However, not all parents responded negatively to the diagnosis of their child's hearing-impairment. This seemed to be related to how ill the child generally was at and after birth. One parent, whose child had not been expected to live and who had a number of other problems at birth, stressed that she thought the hearing-impairment to be the least of her worries. She felt "unconcerned" about the hearing-impairment once it had been diagnosed. This was the one child who was diagnosed very early (within the first three months) and had received a neonatal hearing screen. Whether or not this contributed to the family's ability to accept the diagnosis is difficult to determine. However, similar views were expressed by another parent, whose child also had a range of other problems at birth. This highlights that in the presence of other serious problems, hearing impairment is not necessarily viewed as negatively as it is when the child has no other problems and in all other respects is perfectly healthy.

There also seemed to be some relationship between late diagnosis and the level of anxiety and stress felt. This is discussed in the section on parental views on early screening.

The majority of parents referred to language and communication as being the main area of concern in relation to their child's diagnosis of hearing impairment. They said the thought that their child might be unable to speak or communicate worried them the most, but that they had come to realise their children may be able to communicate despite their hearing loss. The level of concern seemed to be related to the degree of the child's hearing loss. Two parents in the study reported having recently made the decision to learn to sign and enable their child to use sign language, following a lack of success with verbal language. (Both of these children had profound hearing-impairments and were excluded from analyses in the first study – see Chapter Five). One of these parents reported being told by professionals:

"If he wears his hearing aids he will learn how to talk".

This parent expressed some frustration at not having been able to direct her child to the possibility of sign language at an earlier stage. It was only when spoken language was proving an unsuccessful medium for communication for her child that she had sought sign language as an alternative, with successful results. A late introduction to language was also reported by the parent of one other profoundly hearing-impaired child found to have little success developing spoken language.

Fourteen parents in each study (78% and 88%) received no counselling following the diagnosis of their child's hearing-impairment. Of these, three parents in study one expressed a recognisable need for any, while the others felt that the role of counsellor had been met by other professionals involved at the time – audiological scientists, peripatetic teachers, health visitors. This latter view was also expressed by parents in study two. Several parents reported that the peripatetic teacher had been particularly helpful and that having someone with an informed understanding of hearing-impairment in children that could be talked to served a useful purpose. The peripatetic teacher, more than any other professional, was referred to as being a major source of information. The absence of a formal structure in which parents get counselling and advice probably incurs a hidden cost for other professionals (e.g. peripatetic teachers) involved with families at the time of diagnosis. This raises an issue that would need careful evaluation and consideration. One parent, interestingly, suggested that she would have found any counselling at the time of diagnosis unhelpful because of the number of problems that needed to be dealt with at the time. Of those that did receive some form of counselling, this was mainly on genetics. A small subset of parents referred to being briefly involved with a peer support group. These post-hoc reports of the potential value of counselling are difficult to interpret, particularly after parents have successfully moved out of the phase during which they may have benefited from it, had it been available.

6.3 AETIOLOGY

All parents, in both studies, reported receiving minimal amounts of information about their child's hearing impairments following diagnosis. However, there were mixed opinions as to whether or not more detailed information would have been useful. Several parents expressed the view that they were too shocked and upset upon initial diagnosis to have taken in much information. Two parents suggested that a tape recording about hearing-impairment that they could have then listened to at leisure over the following months would have been very useful. And two parents made similar suggestions about written material specifically about their child's impairment. Alternatively, three parents in the first study and five in the second study felt the need for clearer and more detailed information at the time of diagnosis. Two parents in the second study said that the use of terminology that they were unfamiliar with confused clear understanding of the problem. It is interesting that the mixture of suggestions all point at the same underlying issue – poor communication from the health service to parents.

Six parents did not know whether or not their children's hearing-impairments could have been prevented. In all these cases the cause of hearing impairment, according to medical records independently examined, was genetic (confirmed or highly suspected). This could be taken to imply that these parents did not have complete understanding of the nature of their children's hearing impairments. Whether this lack of clear understanding was the result of inadequate availability of information, of miscomprehension on the part of the parents, or some other factor is unclear. It seems highly probable, however, that a lack of understanding about the nature of their child's hearing impairment may have important implications for the way in which parents relate to the child. Therefore, disentangling the factors which may unnecessarily contribute to lack of information for parents could be usefully explored.

6.4 Services Provided

6.4.1 Explanations

Only one parent reported finding explanations at the time of their child's diagnosis to have been very thorough. The other responses ranged from satisfactory to completely insufficient, with the commonest response being that explanations were 'not detailed enough' – 33% of study-one parents and 56% of study-two parents. Study two parents were much more vociferous about the lack of explanations at the time of diagnosis. Nine parents at the end of the interviews made statements directly related to this. One parent expressed the frustration of not being able to empathise with her child. She wanted to know what the hearing impairment would mean to her child in terms of day to day activities and would have valued an explanation that she could translate into real world experience.

6.4.2 INTERVENTION

In 67% of study one cases, children were reported to be receiving one form of intervention alone. The most common form of intervention received by the child, after hearing-aid fitting, was support in the form of a peripatetic teacher visiting the child at home or at school regularly – usually once a fortnight (in 61% of cases). In study two, the parallel figure was 63% (10). In 22% of cases (study one), the main source of intervention was reported to be received by the child within school. In several cases, parents were unclear what this intervention entailed or what exactly the school provided by way of support for their child. Only one child received regular speech therapy, although a number of parents said they had expressed a wish for their child to receive it but were still waiting.

However, amongst study two participants there was a higher degree of provision of more than one form of intervention. Seventy-two percent of the children were in receipt of two forms of intervention which comprised variably of a peripatetic teacher, support derived from within school, speech therapy (25%) or some other form of educational support. However, whereas few study one parents expressed dissatisfaction with the provision received, four study two parents expressed dissatisfaction. Overall, the majority of parents interviewed expressed satisfaction with the provisions that they were receiving and particularly with the services received post-diagnosis of their child's impairment.

This difference in post-identification intervention provision may be due to a number of factors: (i) the availability of support and interventions may have improved in the time between study one and study two (approximately one year); or (ii) the participants in either study one or study two may reflect a skewed picture of general service provision. It was difficult to disambiguate between these possibilities.

As mentioned earlier, many of the participants stressed the important psychological and emotional support that seemed to be derived from the peripatetic teachers who visited the home. For several parents, the teachers were considered to be the main vehicle through which they had gained a clearer understanding of the child's hearing-impairment and come to terms with the potential consequences and their own anxieties. They had been an important source of information.

The inability to see hearing assessments being performed and a lack of clear explanations have been identified as factors which contribute to parents' stress when their child is suspected of having a hearing-impairment (NDCS, 1990). A number of parents reported that one of the most stressful periods was awaiting results from diagnoses. This was particularly reported by parents whose children had been referred to hospital for ABR (Auditory Brainstem Response) or TEOAE. In these situations, parents felt that they were not given a clear explanation of what was occurring, that they had been prevented from accompanying their child during assessment, and that the feedback and 'results' were vague. Two parents stressed that they felt the testers in these situations were particularly unsympathetic to the predicament in which the parents found themselves, and clearer information would have been useful during this process.

6.4.3 HEARING AIDS

All children in the study wore hearing-aids. Of parents interviewed, 67% (N = 12) in the first study and 94% (N = 15) in the second study felt that their child derived some benefit from wearing hearing aids. The majority felt that the benefits were derived in a wide range of situations, including playing outside and communicating during dyadic interactions with a parent or friend. Two parents felt the particular benefit was when the child was out alone being able to respond to being called. However, 17% (N = 3) of parents did not feel that their child benefited from wearing hearing-aids. In all cases these were parents of profoundly hearing-impaired children. The remainder were unsure.

On a similar question, relating to whether or not parents felt their child made *effective* use of hearing aids, overall in 60% of cases the response was affirmative. However, the remainder were unsure, and two participants felt that the hearing-aids were of limited or no value. Again, in both these cases the children involved had profound hearing-impairments and minimal spoken language. In both cases, the children involved were using sign language as their main mode of communication.

The majority of parents reported encouraging their child to wear hearing-aids (78%). However, four parents admitted that they did not encourage their children to wear them – in two cases because they felt that it was unnecessary to do so, and in two cases because they felt that the hearing-aids were of no benefit to the child (as reported above).

6.5 VIEWS ON EARLY SCREENING

> *"I think it is important because I think if you don't do it early, the longer the child waits the less input they get and it obviously does make a difference because you see the response. And I don't think it should be voluntary, I think it should be compulsory."*

This was one mother's view on early screening. All the mothers' who took part in the study, without exception, were positive about the prospect of a neonatal hearing screen and felt that early detection was important. These responses may have been indicative of a selection bias operating on participants. It may be that families more involved in issues surrounding childhood hearing-impairment were more likely to volunteer to take part in the study. All parents, except one whose child was detected following a neonatal screen, felt that their own child could have benefited from earlier detection. Eight families (44%) in the first study and nine (56%) in the second specifically stated that they felt that their own child's hearing-impairment could have been detected earlier and that the delays experienced were unnecessary and avoidable. Parents who were referred to the hospital for an assessment using transient evoked oto-acoustic emissions (TEOAE) also expressed that they could not understand why this test could not have been performed earlier on their child. In all cases they felt that the delay was to the child's disadvantage. The view that later detection and diagnosis somehow contributed to greater shock at the time the child is diagnosed was also expressed by one parent.

However, four parents (across both studies) whose children had been tested early and passed, only to have their hearing-impairments diagnosed later, expressed some concern over the effectiveness and reliability of the tests employed. They seemed to have some concern over the effect of a false negative result, having experienced this themselves and questioned the range of tests available and their sensitivity for hearing impairments in young children.

6.6 CONCLUSIONS

There were a mixture of responses to some of the questions relating to diagnosis and detection. However, there was also a high degree of consistency and agreement in the responses of this group of parents to some of the questions asked. Most parents, for instance, expressed the need for more information at early stages following diagnosis. There was some indication through parents' responses that, if parents are more informed about the potential causes and consequences of their child's hearing-impairment, this may alleviate some of the anxiety, guilt and shock felt immediately after diagnosis. This viewpoint was reflected in several parents' responses to the initial confirmation of their child's hearing impairment. However, it would be useful to determine if the provision of more *parental* support and information relates to improved outcomes for the child. Related to this is the suggestion that the provision of information *prior* to screening for disorder may work to alleviate some anxiety for parents, should a positive diagnosis of their child then ensue. This may be usefully integrated into an intervention programme and may be important for ensuring swift parental orientation to the fact that their child is hearing-impaired.

While the technology which enables infants to be tested for hearing-impairment at younger and younger ages improves, there needs to be corresponding empirical research on some of the key questions related to hearing-impairment and its successful management. Parent responses to these questions suggest that earlier detection is viewed as important and necessary and one parent stressed that it should not be voluntary in order for it to be successful. However, no parents expressed concern over the services which might be available following very early detection (although some questioned the sensitivity of such tests). It may be the case that parents feel less concerned with service provision, and more concerned with their own ability to appropriately support their child's development following detection.

Some conflicting views on the function of the health visitor screen arose from responses. Most parents in the sample had attained a referral for their child's hearing to be assessed via their health visitor. As such, the health visitor intervention was viewed by some parents as having been instrumental in referring a number of children whose hearing-impairments may have gone unnoticed for longer periods. However, this does not necessarily mean that without health visitors referrals would not have occurred. There was some suggestion that parents waiting for an imminent health visitor screen may have compounded a delay in their child's detection and diagnosis. In addition, some parents reported frustration and anger at not having been able to get a referral as a result of their child having passed a health visitor assessment.

The point to be addressed may be in relation to how parents are informed of the availability of hearing assessments for their child. It may be that some families, less familiar with health service provision and procedure, were at a greater disadvantage than those who had some knowledge of the services available. Comparable inequalities in attaining post-identification intervention may also exist.

Parental anxieties following detection of a child's hearing impairment, for hearing parents, have not been fully considered, and few studies have evaluated the sensitivity of services provided in light of these anxieties. More detailed consideration of the pre- and post-identification needs of the family, as well as of the hearing-impaired child, may be particularly important in light of increasing pressure and support for more widely implemented early hearing-screening programmes. Service provision needs to aim to optimise outcomes for hearing-impaired children, and their families may play an essential role if some of their potential needs are directly addressed by intervention programmes.

There was a great deal of support for earlier intervention amongst the parents interviewed. This was unrelated to the severity of the child's hearing impairment; parents whose children had mild-moderate hearing-impairments also expressed the wish for earlier detection. If districts are to move towards universal neonatal screening procedures, as some already have, the impact of testing procedures and methods of result dissemination on the families of hearing-impaired children need to be thoroughly evaluated. In addition, the provision of accessible information and the implementation of carefully thought-out habilitation and intervention for the parents of hearing-impaired children may serve to contribute in beneficial ways to the success of outcomes for these children.

The influence of these factors on children's outcomes need to be evaluated. Within these studies, it would have been interesting to ascertain how parents utilised the period between referral/diagnosis and hearing-aid fitting, given that this can often exceed six months. It may be found that there are important factors which correspond to 'intervention' that lie in the domain of family dynamics and attitudes towards a recently detected hearing-impaired child. The identification of such factors, if they exist, may usefully inform any pre-detection service provision that might be made available to families.

CHAPTER SEVEN

GLOSSARY OF ABBREVIATIONS

LANGUAGE MEASURES

ABUTTS	proportion of abandoned utterances
MLU	mean length of utterance
MLU.COM	MLU derived from complete and intelligible utterances only
MLU.TOT	MLU derived from total language transcript
MPM	morphemes per minute
PNV	proportion of non-verbal utterances
PQU	proportion of questions
SIGNS	proportion of signs used
TUA	total utterance attempts per minute
UNACKTURNS	proportion of unacknowledged turns
UTTS.MZ	proportion of utterances in mazes
VOC	vocabulary
WDROOTS	number of different word roots
WPM	words per minute

DEMOGRAPHIC VARIABLES

AGE	age of child at time of participation in study
AGE.APP	age of child at first appointment at CHAC
AGE.DIAG	age of child at initial diagnosis
AGE.FIT	age of child at hearing-aid fitting
AGE.REF	age of child at time of referral to CHAC
SEG	socio-economic group

SUFFIXES TO LANGUAGE MEASURES

F100	derived from first hundred utterances
L100	derived from last hundred utterances
MOT	relating to mother's language

SUBJECT GROUPS

SN	sensorineural hearing impairment
COND	conductive hearing impairment
CONT	normal hearing (control)

OTHER

BEA	Better Ear Average
LRA	Left/Right Average
dB HL	Decibels Hearing Level
CHAC	Children's Hearing Assessment Centre (Nottingham)
NICU	Neonatal Intensive Care Unit
OME	Otitis media with effusion
MILD	Hearing impairment of 20-40 dB HL
MODERATE	Hearing impairment of 41-70 dB HL
SEVERE	Hearing impairment of 71-95 dB HL
PROFOUND	Hearing impairment of 95+ dB HL

CHAPTER SEVEN

7.1 INTRODUCTION

One aim of the second study was to further explore findings from the first study. The study incorporated groups of children with (i) sensorineural hearing impairment, (ii) conductive hearing impairment and (iii) normal-hearing. As a large proportion of hearing-impaired children spend time after birth in neonatal intensive care, it was decided to include this as an additional stratifying variable. Thus all children in the study were stratified according to whether or not they had spent time (longer than 24 hours) in the neonatal intensive care unit (NICU) postpartum.

At the initial stages of the study it was hoped that data would be collected on six participant groups all of which contained both NICU and non-NICU children: sensorineural hearing-impaired (SN), conductive hearing-impaired (COND), and normal-hearing children. However, the prevalence of children in the NICU population with other problems, compounded by a lower than anticipated uptake rate by potential participants, resulted in the modification of this design.

In addition to the high occurrence of other problems in hearing-impaired NICU children, the difficulties of obtaining sufficient numbers of children, with particular prerequisites to meet group conditions, was further affected by a range of factors. These included the prevalence of hearing impairment in the general child population within the targeted district, the heterogeneity of hearing-impaired children, and problems in ascertaining accurate thresholds early for younger infants, particularly those with mild-to-moderate hearing impairments. All these factors made cross-cell case matching difficult and contributed to a modification of the original design of the study. One result is that only a very small subset of NICU children were represented in the final study.

7.1.1 AIMS AND OBJECTIVES

The second study aimed to investigate the effects of hearing threshold level, age of intervention and a number of other factors (e.g. mothers' language and demographic characteristics) on the spoken language performance of hearing-impaired children. The study employed a similar methodological framework to the first study (see Chapter Five), with attention paid to certain limitations that were identified there.

A new group of sensorineurally hearing-impaired children were identified and tested using a similar procedure and assessment schedule to that in the first study. Language samples from hearing-impaired children in the first study were also re-analysed and incorporated in analyses. Re-analysis involved deriving language measures for these children as detailed in section 7.2.3 below. This varied from the way in which measures were derived in the first study in the following ways:

(i) Language measures were derived from a 100-utterance corpus as well as from the entire recorded episode of interaction, and (ii) Additional language measures – WDROOTS, UTTS.MZ, SIGNS AND MPM – were derived.

The influence of other factors was also evaluated. Additional background information was sought from parents about the children's general health and about family demographics (parental education) and patterns of parent-child interaction, all of which had not been ascertained in the previous study. In addition, data was collected on a small subgroup of normal-hearing children with histories of conductive hearing impairment.

As no control data had been collected in the first study, a group of normal-hearing children were also selected. The children were targeted to match the subjects from the first study with a view to examining how performance on the language measures might vary in comparison.

Therefore, the third study targeted groups of children with:

(1) congenital sensorineural hearing impairments (SN2)

(2) a history or presence of conductive hearing impairment (COND)

(3) normal-hearing - to provide data for comparison (CONT) with hearing-impaired children from the initial study (SN1).

Potential subjects came from records at the Children's Hearing Assessment Centre (CHAC) at Nottingham's General Hospital and (for NICU children) Nottingham City Hospital's Child Development Unit and Department of Neonatal Health and Medicine. For all three groups, the study targeted children born in the Nottingham District Health Authority in the birth cohort 1984/5 to 1988/9. Subjects were therefore aged three to seven years at the time of the study.

7.1.2 (1) THE CONDUCTIVE GROUP (COND)

Subjects were chosen on the basis that they were or had been patients of the Ear, Nose and Throat (ENT) clinic at the Children's Hearing Assessment Centre, having been referred because of a suspected middle ear/conductive hearing condition. In all cases this was identified as Otitis media, in some cases with effusion (OME).

Of 22 potential subjects invited to take part, only eight families (36%) entered the study and one family were subsequently unable to participate. While it is unclear why there was such a low uptake rate amongst families in this group, a marked skew in terms of socio-economic group (SEG) was observed amongst participants. The modal socio-economic group was SEG-3 (unskilled manual employment) with no families found in bands SEG-1 or SEG-2 of the grouping scale.

In addition, four of the subjects had twin siblings (two dizygotic twin pairs and two monozygotic), for whom data was also collected. Of these, two children had conductive hearing losses and three had normal hearing. Thus, the conductive group eventually contained nine children (seven different families and two twin siblings of targeted children), eight boys and one girl, all with a history of conductive hearing problems. **Table 7.1** presents information relating to the subjects in this group.

Data pertaining to interventions received, and age of first clinic appointment, were documented for all these children. Five of the children had received surgical intervention (bilateral grommets, adenoidectomy) for their disorders, two had been treated with antibiotics, and two had received no intervention. For some of these children, various combinations of intervention were received. Individual profiles relating to these children can be found in the Appendix.

Table 7.1 – Subjects of the conductive group. This group is atypical in that all the children are also NICU graduates. More detailed information relating to the subjects' conductive hearing impairments can be found in the Appendix.

	Subject	Age	Sex	Age at first clinic	Intervention	NICU
1	RM[1]	49	male	16	bilateral grommets x2 / adenoidectomy	yes
2	MM	49	male	16	none	yes
3	DH	59	male	11	bilateral grommets	yes
4	RN	62	male	17	antibiotics	yes
5	BA[2]	65	male	14	antibiotics/bilateral grommets	yes
6	LL	77	female	9	bilateral grommets	yes
7	AM	79	male	15	bilateral grommets	yes
8	BM[3]	79	male	15	antibiotics	yes
9	JK[4]	87	male	—	none	yes
	Mean (s.d.)	**67 (14)**		**14 (3)**		

[1] Child is twin of MM.
[2] Child has normal-hearing twin (PA).
[3] Child is twin of AM.
[4] Child has normal-hearing twin (MK).

7.1.3 (2A) THE SENSORINEURAL GROUP (SN)

Subjects were chosen on the basis that they had bilateral congenital sensorineural hearing impairments without other problems that might affect language development or intelligence. On the basis of these criteria, 26 children were targeted.

Of 26 potential subjects, 18 (69%) entered the study. Of these, three children were subsequently found to fulfil the NICU subject category, having spent time in NICU after birth. Therefore, the non-NICU sensorineural group eventually contained 15 children (nine boys and six girls) - 83% of affirmative respondents. This included three children who had participated in the first study a year earlier and volunteered to participate in the second study. All children wore bilateral hearing-aids, spoke English as their first language and came from hearing, English-speaking families. Unaided hearing thresholds in this group ranged from mild (37 dB HL) to profound (100 dB HL). **Table 7.2a** presents information relating to the subjects in this group.

Table 7.2a– Subjects of the sensorineural group (SN2). The age, sex and hearing level in dB HL (BEA better ear average and LRA is left/right average) for each child is presented. Age at referral, first appointment, diagnosis (confirmation of hearing impairment) and hearing-aid fit represent age of intervention, and it is indicated whether or not the child was in Neonatal Intensive Care (NICU) after birth. The final column indicates whether or not children also took part, a year earlier, in the first study.

SN2	Subject	Age	Sex	BEA	LRA	Age at Referral	Age at Appoint	Age at Diagnosis	Age at HA Fit	NICU	Study One
1	AFI	36	male	94	96	2	3	4	4	no	no
2	AC	46	male	46	49	10	15	30	41	no	no
3	RW	52	female	100	103	9	10	11	13	no	no
4	AL	54	male	52	53	8	9	9	14	no	no
5	MHo	57	male	83	86	4	6	10	18	yes	no
6	JA_2	60	female	59	61	13	14	21	21	no	yes
7	JC	61	male	97	104	8	10	10	11	no	no
8	AFo	66	male	96	102	24	27	27	28	no	no
9	CC	70	female	100	102	9	10	10	38	no	no
10	MHa	71	female	37	41	59	60	60	60	no	no
11	JM	71	male	95	95	27	29	29	12[1]	no	no
12	SN	72	female	91	103	19	21	22	23	no	no
13	AA_2	80	male	81	83	33	34	34	34	no	yes

continued overleaf

[1] Child was referred to CHAC on parental request, having been diagnosed and aided elsewhere. Age at referral, first appointment, diagnosis and hearing-aid fit are set at 12 months in subsequent analyses.

Table 7.2a (continued)

SN2	Subject	Age	Sex	Better Ear Average	Left/Right Average	Age at Referral	Age at 1st Appoint	Age at Diagnosis	Age at HA Fitting	NICU	pilot study
14	AB	80	female	63	63	10	12[1]	10	13	yes	no
15	DM	80	male	54	56	4	7	15	50	yes	no
16	NC	81	female	96	103	33	34	34	34	no	no
17	SB_2	83	female	75	78	37	38	38	39	no	yes
18	CJ	85	male	40	41	9	17	17	43	no	no
	Mean (s.d.)	**67 (14)**		**76 (23)**	**78 (24)**	**18 (15)**	**20 (15)**	**22 (14)**	**28 (16)**		

[1] First appointment at CHAC; child had already received earlier diagnosis from elsewhere.

7.1.4 (2B) THE SENSORINEURAL GROUP (SN) – NICU SUBGROUP

Subjects were chosen on the basis that they had bilateral congenital sensorineural hearing impairments, had spent time in NICU, and had no other complicating problems which might affect language or intelligence. Twenty-four children were initially selected, but examination of medical records revealed that a high proportion of them had an additional disability which made them unsuitable for inclusion in the study. NICU children are at high risk for various disabilities and neurodevelopmental disorders, so the high proportion of additional problems in this group was not unusual. **Table 7.2b** details the range of additional problems that were found amongst NICU graduates considered for inclusion in the study.

Table 7.2b – Examples of 'other problems' found amongst NICU children. Better ear average (BEA) is in dB HL.

Child	BEA	Sex	Observations/Other Problems
C1	40	female	Secretory otitis media, no response in other ear at highest thresholds, other problems – not specified.
C2	70	female	Severe developmental delay, myopia, dysmorphology & absent corpus callosum.
C3	48	male	Developmental delay, ward of court.
C4	39	female	Pierre-Robin syndrome.
C5	–	male	Down's syndrome.
C6	63	male	Middle ear dysfunction, dysmorphology, developmental delay, visual problems.
C7	–	male	Mixed hearing impairment, severe developmental delay, large no. of problems (unspecified).
C8	104	male	Mixed hearing impairment, hydrocephalus.
C9	–	male	Syndrome, limb abnormalities, spoken language severely restricted
C10	70+	male	Monosomy 9 syndrome, difficult to assess due to range of other problems.
C11	–	female	Mixed hearing impairment, cerebral palsy, epilepsy, quadraplegia.
C12	62	female	Stickler syndrome.
C13	–	male	Multiple handicap.
C14	80	male	Severe visual and motor impairments, developmental delay.
C15	57	male	Facial dysmorphology, no spoken language development.

Taking these into consideration, the majority of subjects were deemed to be unsuitable for the study. A further difficulty of finding candidates for this subgroup lay in the difficulty of accessing medical records at the City Hospital which was undergoing considerable re-development and re-organisation at the time of the study. It was therefore decided that no subjects would be specifically targeted within this group.

However, an examination of records pertaining to the SN-non-NICU subjects (above) and those subjects who had participated in the first study, five NICU children were identified. Thus, these five children make up the NICU sensorineural subgroup. Information relating to the subjects in this subgroup can be found in **Tables 7.2a** and **7.2c.**

Audiological information for all the sensorineural children (assessments, age of intervention etc.) was derived from medical records at CHAC. In addition, information was requested from Educational Services and the Hearing impairment Regional Support Teams (comprising teachers of the deaf and speech therapists) for details about any rehabilitative services being provided for the children. Information pertaining to only 12 (37%) of the SN children was provided relating to the frequency and type of support received.

Table 7.2c details the sensorineural subjects from the first study whose data was re-analysed and added to the pool of data collected for new sensorineural subjects.

Table 7.2c – Subjects of initial study (SN1). The age, sex and hearing level in dB HL (BEA better ear average and LRA is left/right average) for each child is presented. Age at referral, first appointment, diagnosis (i.e. confirmation of hearingloss) and hearing-aid fit represent age of intervention, and the final column indicates whether or not the child was in Neonatal Intensive Care after birth.

SN1	Subject[1]	Age	Sex	BEA	LRA	Age at Referral	Age at Appoint	Age at Diagnosis	Age at Fit	NICU
1	TW	32	male	78	78	10	11	11	27	yes
2	JA	37	female	50	57	13	14	20	31	no
3	KWo	47	female	85	87	2	3	18	19	no
4	VR	53	male	38	41	10	11	11	16	no
5	CN	54	male	54	55	39	41	41	42	no
6	JH	57	female	96	100	9	9	9	11	no
7	AA	57	male	65	67	33	34	34	36	no
8	SB	61	female	69	73	37	38	38	39	no
9	KWi	61	female	44	44	44	44	44	44	no
10	JCa	65	female	74	76	16	20	17	18	no
11	TH	67	female	37	67	37	43	43	44	no
12	WW	69	male	81	84	48	52	52	54	no
13	DA	73	male	50	59	9	10	23	32	no
14	KH	74	female	75	76	9	13	13	18	no
15	JCl	79	female	91	96	12	13	13	22	yes
	Mean (s.d.)	**59 (13)**		**66 (20)**	**71 (17)**	**22 (16)**	**24 (16)**	**26 (15)**	**30 (13)**	

[1] One child with Down's syndrome who took part in Study One is omitted from this study, thus N = 15.

7.1.5 (3) THE NORMAL-HEARING GROUP (CONT)

Members of the normal-hearing or control group were required to have:

i normal hearing in both ears

ii negligible history of middle ear disease

iii no other known problems which might affect language development or intelligence.

There is a high incidence and prevalence of middle ear disorder, particularly Otitis media, in the age group targeted. Therefore, it could be reasonably assumed that some children targeted for inclusion in this group may have had a history or presence of significant middle-ear disorder. Therefore, children were precluded from the control group if they had had:

i more than two bouts of ear infection during the last 12 months

ii an ear infection that lasted for two or more weeks

iii an ear infection that warranted referral to ENT.

To verify medical records on the above, all parents were questioned before and during the interview about any ear problems experienced by the child.

It was suggested, in Chapter Five, that the observation of delayed language, or other factors, may for some children influence the detection of, particularly mild, hearing impairment. Consequently, it was of concern that 'normal-hearing' participants did not have any undetected hearing or language problems, and that they would serve as matched controls for SN1 children. In consideration of this, an additional criteria was introduced into the selection of the normal-hearing children for the control group.

Children were targeted from a pool of children who had been referred to CHAC for hearing assessment *once* but were subsequently found to have normal hearing. In addition, children were *excluded* if:

(i) any type of specific speech or language disorder or delay was suspected or had been diagnosed,

(ii) language development was of any concern to professionals at the time of interview, or

(iii) a referral to a speech therapist had been made for the child.

Subjects were also chosen to match (on age, sex and demographic variables) the sensorineural children who had taken part in the first study (SN1).

By selecting normal-hearing children in this way, the chances of incorporating a normal-hearing child with a history of middle-ear disorder (in particular Otitis media) were minimised. If the children had been selected from a general population (e.g. school), it would have been far more difficult to establish that children met the criteria outlined above (in relation to ear problems and language problems). The sweep test, for instance, commonly employed in schools to assess hearing problems, is known to be of limited reliability and accuracy. As such, selecting the normal-hearing children via CHAC ensured that reliable hearing assessments had been conducted on all of them, thus establishing hearing status. The following criteria summarise selection of control subjects:

- They had been referred once to CHAC for a hearing assessment and were found to have no problems with their hearing at the time of assessment (sensorineural or conductive).
- They had not been referred to CHAC via a speech therapist or from CHAC to a speech therapist.
- They had no other identifiable problems thought to affect language development or intelligence (e.g. attentional-hyperactivity disorders, specific language impairment).

Of 22 potential subjects, 10 children (46%) (eight boys and four girls) entered the study. One child was subsequently suspected to have a specific language disorder at the time of interview, and his results are thus excluded from all analyses. In addition, two normal-hearing twin siblings of children in the conductive group were added to this group. Thus, the control group finally consisted of 11 children (see **Table 7.3**). There was a shortfall in the number of normal-hearing children because of the low participant uptake rate.

Table 7.3 – Subjects of the control group

	Subject	Age	Sex	NICU
1	LBc	51	female	no
2	JCc	54	male	no
3	RMc	54	male	no
4	SHc	57	male	no
5	AAc	59	male	no
6	MHc	62	male	no
7	SDc	62	female	no
8	PAc	65	female	no
9	DMc	72	male	no
10	CFc	81	female	no
11	MKc	87	male	yes
	Mean (s.d)	**64 (12)**		

Participants

Table 7.4 – The numbers of children, by group, who were invited and agreed to take part in the second study. The percentage of affirmative responses as a proportion of those initially invited to take part are presented in brackets. The number of children from NICU in each group is also detailed.

Hearing status	Invited	Accepted	Participated	Data used	Total	NICU
conductive	22	8 (36%)	7	7[1]	9	9
sensorineural	26	18 (69%)	18	18	18[2]	3
control	22	10 (46%)	9	11[3]	11	2
Total	70	36 (52%)	34	36	38	14

[1] Data also collected on two twin siblings of participants meeting criteria for inclusion into this group.
[2] When SN1 children incorporated, SN total = 33.
[3] Figure includes two normal-hearing twins of two conductive children.

7.2 METHOD AND PROCEDURE

7.2.1 METHOD SUMMARY

The methodology employed is detailed in Chapter Four (4.3), which also details the equipment used and the procedure undertaken.

To summarise:

All children were visited in their own homes by the same interviewer. Some modifications were however made in this study to the procedure employed in the first study. These were as follows:

It was stipulated that each child taking part in the study should ideally be seen with only *one* parent. In all cases this was the mother. It was requested that, if possible, no other siblings be present during the session, particularly the recorded interaction-session between parent and child. However, in 38% of cases this requirement proved difficult for families to meet. This was particularly the case in instances where the child had a twin sibling, or sibling of close age, and the parent had been unable to make alternative arrangements for the sibling on the day of the interview. In some instances the interviewer would occupy the sibling, while recording of the interaction between parent and child took place.

In addition to the equipment outlined in Chapter Four (section 4.3.2), the IHR-McCormick Toy-Test was incorporated in sessions in this study. Where possible, this permitted an assessment of the child's operative hearing threshold (aided-threshold in the case of hearing-impaired children) for speech sounds both in quiet and in noise. The game-like nature of the assessment meant that it was easily incorporated and the children often responded readily to the requirements of the test. A measure of the background noise in the environment of the home, where the assessment took place, was also conducted.

The Annett Peg Task was administered in order to assess the children's dexterity and dextrality.

For recording purposes, a Sony digital audio tape (DAT) recorder was used in place of audio recording equipment utilised in the first study. This provides a higher quality of recording output which could also lend itself to spectrographic analysis if necessary. The recorder was attached to a remote radio microphone in order to permit the child a degree of freedom of movement. It also meant that the radio receiver and recording equipment could be placed out of sight of the child, if environmental constraints permitted.

7.2.2 PROCEDURE SUMMARY

The data-collection session included the same stages as those in the initial study with the addition of an assessment of hearing (for speech sounds), assessment of background environmental noise, assessment of motor skill - dexterity/dextrality (Peg Task) and an extended background information questionnaire. The stages which comprised the session are summarised below.

Outline of general procedure employed during home visits:

STAGES OF SESSION
Stage 1 Introductions and setting up of equipment
Stage 2 General questionnaire (including questions on language and communication in everyday situations and attitudes to services provided) - completed in semi-structured interview format
Stage 3 Test of functional hearing for speech sounds using IHR-McCormick Toy Test in quiet and in noise; measure of background noise
Stage 4 Administration of Annett Peg Task
Stage 5 Audio and video tape recording of interactive play session between mother and child (mean recording time 35 minutes)
Stage 6 Feedback and departure

7.2.3 LANGUAGE MEASURES

All language samples were transcribed according to conventions outlined in Chapter Three (3.2.3). An example of transcription can be found in the Appendix. All transcripts were checked at least three times against recordings once complete, and a sample was transcribed by an independent transcriber. Inter-transcriber reliabilities ranged from 0.78 to 0.95 ($p<.05$).

A series of overt macro-level language measures were derived for all the children. These measures were divided up into three broad categories - relating to (i) syntax, (ii) rate of speaking and (iii) interaction and are presented in **Table 3.2** (Chapter Three).

The **Syntax** category variables were: mean length of utterance (MLU), vocabulary (VOC), number of signs used (SIGNS), number of different word roots (WDROOTS) and the number of utterances containing mazes (UTTS.MZ).

The **Rate** category variables were: the number of words per minute (WPM), morphemes per minute (MPM) and the number of total utterance attempts per minute (TUA).

The **Interaction** category variables were: the proportion of questions (PQU), the proportion of non-verbal utterances (PNV), the proportion of unacknowledged turns taken (UNACKTURNS) and the proportion of abandoned utterances (ABUTTS). The arcsin root transformations of these variables were also used in analyses.

One limitation of the first study was that language measures were derived from language transcripts generated from the entire recorded episode of interaction for each subject. The number of utterances per subject were not controlled.

Several researchers have shown that some language scores are influenced by the number of utterances from which they are derived. Measures of type-token ratio, for instance, have been shown to be positively correlated to the number of utterances comprising the language sample from which they are calculated (Richards, 1988). In the first study, an average of thirty-five to forty minutes of interaction were transcribed for each child. This resulted in transcripts containing a wide range of number of utterances and may have resulted in unreliable differences in scores for some of the language measures (e.g. VOC).

As a result, all language measures in this study were derived from the first 100 and, for some measures, the last 100 utterances of the entire language sample. This produced two scores for each language measure. Bivariate correlational analyses were used to compare the measures derived from the first and last 100-utterance samples. These revealed high correlations between the measures for all subjects (e.g. MLU: r = .80, $p < .001$; VOC: r = .72, $p < .001$). This suggests the first 100-utterances to be generally representative of the whole language sample recorded for participants.

By default, analyses are based on the language measures derived from the first-100 utterances of the language sample. Therefore, where there is no suffix, the language measure has been derived from the first 100 utterances. Where a distinction is necessary, the suffix F100 (e.g. MLU.F100) distinguishes that the language measure was derived from the first 100 utterances of the language sample, while the suffix L100 (e.g. MLU.L100) denotes that the measure was derived from the last 100 utterances of the language sample.

A subset of the language measures was derived from the entire transcript, as well as from the first 100 utterances. These were MLU (MLU.COM AND MLU.TOT) and the rate measures – WPM, MPM AND TUA. The number of different word roots (WDROOTS) was derived *only* from the entire recorded episode for each child (mean length of recorded episodes = 35 minutes).

Subject-group mean scores for the language measures are presented in **Table 7.5**. Group differences in these language measures are considered later in this chapter (see section 7.4).

Table 7.5 – Mean scores on main outcome variables for all subject groups - SN1, SN2, SN1 and SN2 combined, COND and CONT groups. There was no statistical difference in age between the groups and analysis of variance revealed significant differences in the PQU and UTTS language scores between the groups.

Language Measure		Group				
		SN1 (N = 15)	SN2 (N = 18)	SN (comb) (N = 33)	COND (N = 9)	CONT (N = 11)
Age	Mean (s.d.)	59 (13)	67 (14)	63 (14)	67 (14)	64 (12)
MLU (com)	Mean (s.d.)	2.7 (0.8)	3.3 (1.0)	3.0 (0.9)	3.6 (0.8)	3.4 (0.7)
MLU (F100)	Mean (s.d.)	2.7 (0.7)	3.2 (1.0)	3.0 (0.9)	3.6 (0.9)	3.3 (0.7)
MLU (L100)	Mean (s.d.)	2.8 (0.9)	3.5 (1.0)	3.2 (1.0)	3.5 (0.9)	3.7 (0.8)
MLU (wqu)	Mean (s.d.)	2.6 (0.8)	3.2 (1.0)	3.0 (0.9)	3.3 (0.9)	3.3 (0.8)
MPM	Mean (s.d.)	26.9 (10.7)	28.3 (9.7)	27.7 (9.9)	26.8 (14.1)	27.7 (9.4)
PNV	Mean (s.d.)	8.3 (9.5)	7.4 (4.2)	7.8 (7.0)	4.4 (2.1)	5.8 (4.8)
PNV.F100	Mean (s.d.)	8.3 (9.7)	8.9 (5.1)	8.6 (7.4)	4.5 (2.4)	6.5 (4.4)
PQU	Mean (s.d.)	6.1 (3.2)	11.6 (7.3)	9.1 (6.4)	12.2 (5.8)	11.5 (3.8)
PQU.F100	Mean (s.d.)	5.3 (6.1)	12.8 (7.9)	9.4 (8.0)	13.1 (5.8)	11.1 (6.1)
TUA	Mean (s.d.)	9.8 (3.2)	8.9 (3.1)	9.3 (3.1)	7.4 (3.3)	8.4 (3.1)
UTTS.MZ	Mean (s.d.)	13.5 (13.5)	17.1 (11.5)	15.5 (12.4)	15.2 (7.8)	19.0 (16.2)

continued overleaf

Table 7.5 (continued)

The PNV group means are higher for the SN children than either the COND or CONT children, while the COND and CONT children produce larger VOC scores than SN1 or SN2 children. However, only the differences in PNV were found to be significant. In addition, Significant differences in MLU.L100 and PQU were found between SN1 and SN2. Peg scores, using the Annette peg task, were only collected during the second study, thus are unavailable for SN1 children. No significant differences was found on this measure between the groups, nor was the PEG measure found to be significantly related to any of the language measures, or to hearing severity or age of intervention for the SN2 children.

MEASURES		GROUP				
		SN1 (N = 15)	SN2 (N = 18)	SN (comb) (N = 33)	COND (N = 9)	CONT (N = 11)
UTTS	Mean (s.d.)	262 (113)	214 (69)	236 (94)	150 (59)	214 (87)
VOC.f100	Mean (s.d.)	93.9 (31.9)	98.7 (24.1)	96.5 (27.5)	115.9 (11.6)	109.8 (21.3)
VOC.L100	Mean (s.d.)	100.1 (28.7)	101.1 (23.0)	100.6 (25.3)	114.8 (13.7)	117.9 (21.2)
WPM	Mean (s.d.)	24.0 (9.3)	25.7 (9.4)	24.9 (9.2)	24.7 (13.1)	25.0 (8.9)
PEG (diff)	Mean (s.d.)	–	0.8 (1.8)	–	1.6 (1.9)	0.4 (2.2)
SEG	Mode	4	4	4	3	4

7.2.4 HEARING THRESHOLD LEVEL (SN2 CHILDREN)

Hearing threshold levels were ascertained for all hearing-impaired children via records at CHAC. For each child, details were taken from the audiological assessment conducted nearest to the time of interview. In all cases the period between the audiological assessment, from which figures were derived, and the interview did not exceed two months. Details of aided threshold assessments were also noted, as were the results of any speech discrimination tests. Using mean hearing thresholds at .5, 1, 2 and 4 kHz, where available, both better ear average (BEA) and left/right average (LRA) scores were calculated to represent hearing threshold level for each child (full audiological profiles for the children can be found in the Appendix).

It is recognised that one limitation of using these averages to represent hearing level is that the slope of children's hearing impairments (corresponding to low versus high frequency loss) is often masked. However both BEA and LRA are standard measurements of hearing threshold level used in studies involving hearing-impaired subjects. Audiological profiles for all hearing-impaired children in the study can be found in the Appendix.

For the children (N = 3) who took part in both the first and second studies, hearing threshold level was re-calculated from more recent audiograms coincident with the date of the second interview. These children thus have two separate pure tone threshold profiles, one corresponding to the hearing assessment conducted nearest to the time of the first study, and a second corresponding to the assessment conducted nearest the time of the second study. This resulted, in one case (AA_2), to a raised hearing threshold level being recorded for the child as his hearing impairment had progressed (from 67 to 80 dB HL) since his participation in the first study.

7.2.5 AGE OF INTERVENTION

Age of intervention was represented in this study by the following four measures: the age of the child at (i) referral, (ii) first appointment, (iii) diagnosis and (iv) hearing-aid fitting. These measures were derived from a detailed examination of records at CHAC for the new hearing-impaired participants (SN2) and for those children who participated in the first study (SN1). As a result, measures for SN1 children were updated and checked. In some cases a small discrepancy (of no more than one month) was found between values used in the first study for these variables and those found in records examined. However, these discrepancies were found to make no significant difference to mean or median values for this group of children. Nor were they in any way found to affect the patterns of results obtained and presented in Chapter Five.

Before the results are presented, differences between the sensorineurally hearing-impaired children (SN1 and SN2) are considered and the groups are compared on age, age of intervention and hearing threshold level.

7.2.5 SENSORINEURAL HEARING-IMPAIRED CHILDREN: GROUP COMPARISONS

Differences in age, age of intervention and hearing level were evaluated for SN1 and SN2 children. Independent t-tests were used to compare the hearing-impaired children from the first study (SN1, N = 15) with those who took part in the second study (SN2, N = 18). These revealed no significant differences between the two groups in terms of mean AGE, age of intervention (AGE.REF, AGE.APP, AGE.DIAG and AGE.FIT) or BEA. The mean and median values for these variables are presented in **Table 7.6** for each group. The median values may be taken as more reliable indicators of the central tendency for each group because of the variance for these variables and the heterogeneity of the groups.

Table 7.6 – Comparison of SN1 and SN2

Mean age at interview, hearing level (better ear average and left/right average) and ages at intervention for sensorineural subjects (groups SN1 and SN2). T-tests revealed no statistically significant differences between the two groups for the variables presented below.

		Age	Better Ear Average	Left/Right Average[1]	Age at Referral	Age at 1st Appoint	Age at Diagnosis	Age at HA Fit	Delay (Fit - Ref)
SN1 (N = 15)	Mean	57.1	65.8	70.7	21.9	23.7	25.8	30.2	8.3
	Median	61.0	69.0	73.0	13.0	14.0	20.0	31.0	6.0
	(s.d.)	(15.1)	(19.2)	(17.4)	(15.7)	(16.2)	(14.6)	(12.8)	(7.2)
SN2 (N = 18)	Mean	66.9	75.4	78.4	17.7	19.8	21.7	27.6	9.9
	Median	71.0	81.8	84.5	10.0	15.0	19.0	26.0	4.0
	(s.d.)	(14.0)	(22.5)	(23.9)	(15.1)	(14.7)	(14.1)	(16.0)	(15.2)

[1] BEA and LRA calculations derived from pure tone audiograms acquired as near to date of interview as possible. Audiogram details are provided in the Appendix.

A review of the mean values indicates slight, but non-significant, differences between the two groups. The second group of sensorineurally hearing-impaired children (SN2) have a BEA 10 decibels higher, on average, than the children in the first study. By contrast, the ages of intervention (i.e. age at referral, first appointment, diagnosis and hearing aid fit) are lower for the SN2 children, with their impairments being diagnosed an average of four months earlier and hearing aids fitted on average two-to-three months earlier than SN1 children. This may be related to the higher mean hearing threshold level found for the SN2 children, or to a general improvement in services during the period between the first and second studies.

To explore the first of these possibilities, bivariate correlational analyses of hearing threshold level and age of intervention were performed for SN2 children. These revealed that there was no significant relationship between hearing threshold level (BEA) and age at referral, first appointment or diagnosis, although a significant negative correlation was found with age at hearing-aid fitting ($r = -.54$, $p = .02$).

This implies that, for the SN2 children in the second study, those with higher hearing thresholds were fitted with hearing aids earlier than those with less severe hearing impairments. (This can be seen more readily by looking at the median values for age of intervention between the SN1 and SN2 groups). This relationship was not observed for SN1 children, where hearing severity was found to be unrelated to age of intervention, including age at hearing-aid fitting. This relationship would have been different, however, had the four profoundly hearing-impaired infants, excluded at the start of study one, been included in analyses.

The difference in AGE.FIT between the two groups may be, in part, explained by the relationship between hearing severity and age of intervention for the SN2 children, who have a higher mean hearing threshold than SN1 children. The differences in AGE.REF, AGE.APP and AGE.DIAG, however, do not seem to be related to hearing severity in the same way.

For both groups combined, the variance for age of intervention ranges from 12 to 16 months, and a large period is found between referral and hearing-aid fitting, which is just over eight months for SN1 children and an average of 10 months for SN2 children. This period is even longer if the median values of AGE.REF are subtracted from median values for AGE.FIT (17 and 16 months respectively). For individual children, this period ranged from one month, for a profoundly hearing-impaired child, to as much as 46 months, for a child with a moderate hearing impairment.

Stratifying the children into two severity groups (mild-to-moderate and severe-to-profound hearing impairments) t-tests revealed that those children with mild-to-moderate hearing impairments typically waited six months longer than children with severe-to-profound impairments for hearing-aids (mean delay for mild-moderate hearing-impaired children = 12.5 months, s = 13.9; mean delay for severe-profound hearing-impaired children = 6.1 months, s = 9.4). However, this difference was not significant.

Summary

While there are some differences in average age of intervention and hearing level between SN1 and SN2 children, none of these were found to be significant. There was also no significant difference between the two groups in terms of AGE. There is some evidence, however, that, amongst the SN2 children, AGE.FIT is related to hearing severity such that children with profound hearing impairments received hearing-aids earlier than children with less severe hearing impairments. A wide range is evident in the age at which children in the sample waited for hearing-aids following initial referral (1 to 46 months).

7.3 RESULTS

The results are presented in three main sections.

Firstly the relationship between AGE and the language outcome measures was evaluated for all subject groups (SN1, SN2, COND and CONT).

Secondly, between-group comparisons of performance on the language outcome measures are presented (section 7.5). This includes a consideration of the effects of sensorineural hearing loss on the language measures by grouping participants into SN and non-SN groups and evaluating differences in scores. The effects of other factors, such as the socio-economic group to which the families of children belonged, are also considered.

Thirdly, results for the sensorineural hearing-impaired children (SN1 and SN2) are considered. SN1 and SN2 children are conjoined in order to evaluate the effects on these children's language measures of (i) age, (ii) age of intervention, (iii) hearing threshold level, and (iv) the mothers' language. Correlational analyses and multiple regression were used.

Results (I): Language measures - Effects of age

Language measures, as detailed earlier, were derived for all participants and arithmetic mean scores were calculated for each group of children - SN1, SN2, COND and CONT. These were presented in **Table 7.5**.

7.3.1 All children

Initially, all children's language scores were pooled in order to explore the relationship between AGE and language performance generally. For all the language measures the relationship with AGE was in the anticipated direction; i.e. performance on most of the language measures was found to increase with AGE. However, this relationship only reached significance for three of the measures. Bivariate correlational analyses revealed highly significant positive correlations between AGE and two of the syntax measures MLU (r = .43, $p < .001$) and VOC (r = .45, $p < .001$), while a significant negative relationship was found with PNV (r = -.31, $p < .05$). **Figures 7.1–7.3** present the relationships between AGE and MLU, VOC and PNV respectively.

Arcsin root transformations were also performed on the interaction variables – PNV, PQU and UNACKTURNS as they are proportional measures. The correlation between AGE and the transformation of PQU, but not PNV, yielded a slightly higher, but not quite significant correlation (r = .25, p = .07). In addition, AGE was negatively, but insignificantly, correlated with UNACKTURNS and ABUTTS. None of the rate measures (MPM, WPM or TUA) were found to be significantly related to AGE.

These relationships can be taken to indicate that for some of the language measures at least, an anticipated relationship with AGE was found. And there is some sensitivity in the MLU measure to AGE. It is unclear why only three of the measures were significantly related to AGE. However, this might be a peculiar effect of conjoining the SN, COND and CONT groups together. Factors specifically related to the different subject groups may, predictably, have acted to confound any relationship that might ordinarily be observed between AGE and language outcomes. These are explored below.

7.3.2 SENSORINEURAL GROUP (SN 1 AND SN2)

If the scores derived for only the sensorineural hearing-impaired children are considered (SN1 and SN2), the relationship between AGE and the language measures changes slightly. For this group, in addition to significant relationships being found for MLU and VOC, significant positive correlations were found between AGE and two rate measures - MPM and WPM.

The strongest relationship was with WPM (r = .49, $p < .005$), followed by MLU (r = .46, $p < .01$), MPM (r = .46, $p < .01$) and VOC (r = .42, $p < .01$). These results imply that older children in this group produced higher scores on these variables. The relationships between AGE and WPM, MLU, MPM and VOC respectively can be seen in **Figures 7.4– 7.7**.

Positive correlations were also found for PQU, TUA and WDROOTS for the children in this group, and a negative correlation was found between AGE and PNV. However, none of these relationships reached significance at the $p < .05$ level. **Figures 7.8– 7.11** present the correlations between these variables and AGE.

7.3.3 NORMAL-HEARING GROUP (CONT)

For the control children alone (N = 11), significant positive correlations were found between AGE and two of the language measures relating to overt syntax. These were MLU (r = .61, $p < .05$) and VOC (r = .62, $p < .05$). By comparison, significant negative correlations were found with UTTS.MZ (r = -.71, $p < .01$) and TUA (r = -.68, $p < .05$). These relationships are presented in **Figures 7.12–7.15**. Thus, for MLU and VOC (syntax measures) higher outcomes were associated with higher age. For UTTS.MZ and TUA, the opposite was found - these measures appear to decrease with age for the normal-hearing children in this group. While the number of utterances in mazes produced by the children might be anticipated to decrease with age, the association between AGE and TUA might be interpreted as an anomaly. It suggests that the older children in the sample were less talkative than younger children taking part in the study.

This might be interpreted as a reflection of an increased self-awareness in the context of the recorded interaction. However, looking at the range of ages in the control group reveals this group to have the smallest variance in age of the four groups – 51 to 87, with a quarter of participants above 72 months of age. Although the mean age of the group was not found to be significantly different from that of other groups, this may have affected outcomes on some of the language measures (e.g. MLU).

7.3.4 CONDUCTIVE GROUP (COND)

For the conductive children (N = 9), surprisingly few of the language measures were found to be significantly associated with AGE. Of them, only PNV (PNV.F100 and arcsin root transformation) was found to be significantly negatively correlated with AGE (r =

-.68, p < .05) - see **Figure 7.16**. None of the syntax measures or rate measures were significantly related to AGE for this group. This may be related to the small number of subjects in the group, or to factors related to group composition, which are considered in later sections.

Summary

Correlational analyses were used to investigate the relationship between AGE and the language measures used in the study. Pooling all subject data (N = 53) revealed significant correlations between AGE and MLU, VOC and PNV, although correlations with the other language measures were in the anticipated direction – i.e. increasing age corresponded to increased scores on appropriate measures.

These relationships were modified, however, when subject groups were considered individually. For SN children (N = 33), AGE was significantly correlated to MLU, VOC, MPM and WPM. For CONT children, AGE was significantly correlated to MLU and VOC, while for COND children, AGE was only found to be significantly negatively correlated to PNV. No significant correlations were found for any of the subject groups between AGE and WDROOTS, TUA, or PQU, even when the arcsin root transformation of PQU was used.

7.4 RESULTS (II): BETWEEN GROUP COMPARISONS

7.4.1 ALL GROUPS: SN, COND AND CONT GROUPS

The mean language scores derived for each group of children were compared to see if there were any significant differences in performance on these measures between the groups. Group means of the language measures are presented in **Table 7.5**.

Analysis of variance was used to compare the measures derived for the four groups of children (SN1, SN2, CONT and COND). This revealed significant differences in PQU ($F(3, 49) = 6.26$, $p = .001$ for arcsin root transformation of PQU) and UTTS ($F(3, 49) = 3.0$, $p < .05$). The difference in MLU was found to approach significance ($F(3, 49) = 2.51$, $p = .07$).

Language measures derived for SN1 and SN2 were then conjoined in order to enable the comparison of outcomes for SN children (SN1 and SN2 combined), COND children and CONT children. A one-way analysis of variance revealed a significant difference between the groups for the proportion of unacknowledged utterances (UNACKTURNS). This was significant for both the child's UNACKTURNS ($F(2, 35) = 5.22$, $p = .01$) and the mother's UNACKTURNS ($F(2, 35) = 5.25$, $p = .01$). The mean group scores for the UNACKTURNS (for both mother and child) are presented below:

Proportion of turns unacknowledged by the child and mother for each subject group, and the proportion of utterances abandoned by the child. There is a significant difference between the groups for mother and child's UNACKTURNS, but not for ABUTTS. Standard deviations are presented in brackets.

LANGUAGE MEASURE	SN	CONT	COND
% UNACKNOWLEDGED TURNS (CHILD)	24 (17)	18 (16)	5 (5)
% UNACKNOWLEDGED TURNS (MOTHER)	14 (14)	9 (17)	0.4 (1)
% ABANDONED UTTERANCES (CHILD)	7 (4)	7 (5)	7 (4)

Children and mothers in the SN group acknowledged the fewest utterances during the recorded interaction. Turn-taking behaviour is an important characteristic of interaction and interpersonal communication. Popular children found to participate in cohesive patterns of discourse, characterised by contingent responses and appropriate turn-taking behaviour (Black and Logan, 1995).

The most significant difference is between the COND and the SN and CONT children – COND children and mothers seem to have significantly fewer unacknowledged turns than either of the other two groups.

No other significant differences were found between the groups, although a difference in VOC was found to approximate significance ($p < .06$). The group scores for VOC are presented in **Figure 7.17**.

There may be a number of reasons why no group differences were found at this stage, other than the differences in UNACKTURNS, perhaps related to the subject composition of the groups, or to factors not accounted for within this analysis. In consideration of these possibilities, the following further group comparisons were conducted.

7.4.2 Comparison of Sensorineural (SN1 and SN2) Children

For most of the language measures, SN2 children produced higher scores than SN1 children. Two exceptions were TUA and PNV, for which the SN2 children had slightly lower scores – TUA: SN1 = 9.8, SN2 = 8.9 and PNV: SN1 = 8.3, SN2 = 7.4. Mean scores for each group are presented in **Table 7.5**.

Independent t-tests were used to compare the language measures derived for SN1 and SN2 children. These comparisons revealed very few significant differences in performance between the two groups. However, differences were found for MLU.L100 ($t(31) = -2.18$, $p < .05$), PQU.F100 ($t(31) = -3.01$, $p < .005$) and WDROOTS ($t(31) = 2.08$, $p < .05$). For MLU.L100 and PQU.F100, SN2 children obtained significantly higher measures, while for WDROOTS, the SN1 children obtained the higher measure.

Differences in MLU.F100, MLU.COM and MLU.TOT were not significant.

These results suggest that the SN1 children were producing longer utterances than SN2 children during the latter period of the interaction, while during the earlier part of the interaction in particular, they were generally asking more questions than SN2 children.

The difference in WDROOTS has to be interpreted cautiously. The most likely explanation for this result is the different number of utterances produced during the *entire* recorded episode between the two groups. Although not significant, SN1 children produced an average of 50 utterances more than SN2 children during the entire recorded interaction, from which the WDROOTS measure was derived. The interactions recorded during the first study were 5-10 minutes longer than those recorded in the second study (mean length in second study = 35 minutes). This possibility was further consolidated when a bivariate correlation of WDROOTS and the number of utterances produced was found to be highly significant ($r = .52$, $p < .005$).

In some of the analyses presented below, the measures derived for SN1 and SN2 children were conjoined. Despite the differences found above, this was not considered to be problematic. For group comparisons, language measures from the first-100-utterances were used – (the two groups did not significantly differ on the MLU score derived from this). Considering the heterogeneity of hearing-impaired children and within-group variance, and allowing for the differences outlined above, the two groups were considered to be sufficiently similar (on the independent and remaining dependent variables) for this to be done.

7.4.3 Comparison of SN and non-SN children

The effect on language scores of sensorineural hearing impairment was examined by comparing the scores of all SN children with those of all non-SN children. Subjects were therefore stratified into two groups - one containing all SN children (SN1 and SN2, N = 33) and the other containing non-SN children (COND and CONT, N = 20).

Comparison of group means revealed a significant difference in VOC – VOC.F100: SN = 96.5, non-SN = 112.6, t (51) = -2.33, p < .05). In addition, the difference in MLU approached, but did not quite reach, significance (t(51) = -1.87, p = .07). For all the variables (except PNV), the non-SN children scored higher than the SN children. For PNV this pattern was reversed (SN = 8.6, non-SN = 5.6). However, these differences were non-significant.

As might be anticipated, performance on the IHR-McCormick Toytest also differed significantly for the two groups, with SN children obtaining an average threshold of 45 dBA compared to 34 dBA for non-SN children. A significant difference was only found when the test was conducted in quiet (t(26) = 3.54, p < .005).

Socio-economic grouping was also considered. Here a marked skew in SEG was found for non-SN children (SEG distribution for SN children is detailed above). For the non-SN group, no families were found from categories SEG-1 or SEG-2 (professional/skilled occupations) of the SEG categorisation scale. Instead SEG was represented by groups 3, 4 and 5 only, with 80% of participant families equally distributed between categories SEG-3 and SEG-4 (semi-skilled and manual occupations).

7.4.4 COMPARISON OF SN1 AND CONT CHILDREN

Children in the normal-hearing group (CONT) were initially selected to provide data with which to compare the performance of the hearing-impaired children who comprise the participants of the first study (SN1). Therefore, it was appropriate to specifically compare language outcomes for these two groups.

A review of group mean values for the language measures (see **Table 7.5**) illustrates that the CONT children attain higher scores than SN1 children on most of the variables, except PNV, for which SN1 children produce higher scores. Independent samples t-tests were used to evaluate differences in these scores. These revealed a highly significant difference for PQU ($t(24) = -3.89$, $p < .001$) and a significant difference in MLU.F100 ($t(24) = -2.06$, $p < .05$). The difference in MLU was also significant for MLU measures derived from complete and intelligible utterances (MLU.COM: $t(24) = -2.36$, $p < .05$) and from the entire utterance corpus (MLU.TOT: $t(24) = -2.14$, $p < .05$).

This finding seems to consolidate the observation made in Chapter Five for SN1 children, when their MLU scores were compared with those derived from Well's data (Wells, 1985). This suggested that the hearing-impaired children had lower scores than hearing peers on this measure. The results thus suggest that SN1 children ask fewer questions (interaction measure) and have lower MLUs (syntax measure) than hearing peers matched for AGE and SEX. The two groups did not differ significantly in terms of modal SEG.

7.4.5 THE INFLUENCE OF OTHER FACTORS: SEG

The possible effect of other factors on children's language measures were considered, and these results are presented below. Factors investigated included the socio-economic group to which children's families belonged, the number of siblings children had, and whether or not other siblings were present during the recorded interaction-session.

EFFECTS OF SEG ON LANGUAGE SCORES – ALL CHILDREN

The general effect of socio-economic grouping on the language measures was considered.

All participants were stratified into two groups representing categories SEG-1 – 3 and SEG-4 – 5 on the socio-economic grouping scale. Group 1 (SEG-1 – 3) contained 26 subjects, Group 2 (SEG-4 – 5) contained 27 subjects.

A relationship between SEG and children's performance on some of the language measures was observed. Generally, Group 1 (SEG-1 – 3) performed better on the language measures than Group 2 (SEG- 4– 5). However, the only significant difference was found for MLU (Group 1 = 3.4, Group 2 = 2.9, $t(51) = 2.27$, $p < .05$).

The effects of SEG on children's language is difficult to interpret. For this particular group of children, there are a range of other factors which make interpretation particularly tenuous. The skewed representation of socio-economic grouping for the COND group is an example that was presented earlier in this chapter.

EFFECTS OF SEG ON LANGUAGE SCORES – SN CHILDREN

In terms of socio-economic grouping, the most common occupational categorisation for participating families in the SN group was SEG-4 (corresponding to unskilled occupations). Taking the usual stratification of participants into SEG-1 to 3 compared to SEG-4 to 5, 50% of SN1 families and 61% of SN2 families fell into the former category (SEG-1 to 3 – professional, skilled and semi-skilled occupations).

For SN children, no significant differences in age of intervention was found between the two socio-economic groupings, although children from SEG-1–3 (N = 18) received their hearing aids six months earlier, on average, than those from groups SEG-4 and SEG-5 (N = 15). It was initially thought that this may have been compounded by hearing threshold level – a relationship between hearing threshold level and age of hearing-aid fitting was earlier established for the hearing-impaired children. However Group 1 participants were found to have a non-significant mean difference of 4 dB HL in comparison to Group 2.

The child language measures for which socio-economic grouping appeared to make a significant difference for the SN children were MLU (Group 1 = 3.3, Group 2 = 2.6, $t(31) = 2.24$, $p < .05$) and TUA (Group 1 = 8.1, Group 2 = 10.8, $t(31) = -2.65$, $p < .05$). For MLU, Group 1 (SEG-1–3) produced a higher mean, while for the TUA measure this was reversed.

Wells (1985) draws attention to the fact that a number of studies have proposed a strong relationship between socio-economic grouping and language development. However, he suggests that these studies often use data derived from extreme categories of SEG (e.g. SEG-1 compared to SEG-5), which serve to provide a distorted illustration of an otherwise tenuous relationship. Outliers – measures in the upper and lower percentiles, often correspond exclusively to these two categories. Their exclusion may alter the relationship between SEG and language performance significantly for the majority of a population under study.

In consideration of this, the relationship of SEG to the language measure MLU was re-evaluated removing children from families in SEG-groups 1 and 5 (the categories at either end of the scale). **Tables 7. 7a** and **7.7b** present the correlations both before and after the removal of SEGs 1 and 5 for all subjects (7.7a) and for SN subjects alone (7.7b).

Relationship between SEG and MLU (i) including subjects in categories SEG-1 to 5, and (ii) excluding subjects in categories SEG-1 and 5:

Table 7.7a

ALL CHILDREN	(I) SEG GROUPS 1 – 5 (N = 53)	(II) SEG GROUPS 2 – 4 (N = 42)
MLU.F100	-.42 (p = .01)	-.35 (p = .08)
MLU.COM	-.53 (p = .002)	-.36 (p = .07)

Table 7.7b

SN CHILDREN ONLY	(I) SEG GROUPS 1 – 5 (N = 33)	(II) SEG GROUPS 2 – 4 (N = 26)
MLU.F100	-.28 (p = .04)	-.24 (p = .13)
MLU.COM	-.36 (p = .008)	-.22 (p = .16)

As can be seen, the removal of those children at either end of the SEG scale results in a non-significant relationship between SEG and MLU. This pattern of relationships remains the same when AGE is statistically controlled.

7.4.6THE INFLUENCE OF OTHER FACTORS: PRESENCE OF SIBLING

Language scores were looked at in relation to whether or not the child had a sibling present during the recorded interaction-session. While every attempt was made to see the study-child alone with the major care-giver, this requirement proved difficult to meet for some families on the day of the interview. The proportion of children in each group (SN, COND, CONT) who had a sibling present during the session is presented below in **Table 7.8**:

	SN	COND	CONT
SIBLING PRESENT	11 (33%)	6 (67%)	3 (27%)
NO SIBLING PRESENT	22 (67%)	3 (33%)	8 (73%)

Overall, for 20 (38%) of the children who took part in the study, siblings were present during the interaction-session from which the sample of child language was derived.

Children were allocated to one of two groups depending on whether or not a sibling was present during the interview – Group 1 = children with sibling present, Group 2 = children without sibling present. Independent t-tests were used to compare group means. No significant AGE difference was found between the two groups (Group 1 = 67, Group 2 = 63). Overall, the differences in mean scores revealed no highly consistent pattern of differences between the two groups. However, significant differences were found between the groups on the following language measures:

MLU.F100 (Group 1 =3.5, Group 2 = 2.9, $t(51) = 2.27$, $p < .05$), **PNV.F100** (Group 1 = 4.7, Group 2 = 9.2, $t(51) = -2.62$, $p < .01$), **TUA** (Group 1 = 7.5, Group 2 = 9.6, $t(51) = -2.44$, $p < .05$) and **UTTS.MZ** (Group 1 = 11.5, Group 2 = 19.0, $t(51)$, $p < .05$).

For all these measures, except MLU.F100, the children without siblings (Group 2) scored higher than the children with siblings. This result might have been anticipated for the rate measure (TUA) as the recorded episode would have involved three as opposed to two interlocutors for some of the children in Group 1, thereby possibly constraining the total number of utterances children in that Group may have produced. For MLU.F100, however, the children with siblings scored higher than those without. No significant group differences were found for MLU.COM, MLU.TOT or MLU.L100, for which the difference in group means was found to be 0.2 morphemes or less.

It was also anticipated that the mothers' language may differ according to whether or not one or two children were present during the interaction. However, comparisons of group means for the mothers' corresponding language revealed no significant differences on any of the language measures in relation to this factor.

Further exploration of the data suggested that the influences of sibling presence may have been different for different subject groups and modified by their inclusion in the above analyses. This is considered below:

NON-SN CHILDREN

Combining COND and CONT groups (N = 20), 45% of the children without sensorineural hearing impairments were recorded with a sibling present. When language performance was considered for these children, as a function of sibling presence, the only significant differences found were on those measures which relate to language productiveness/rate of speaking. These were MPM ($t(18) = -3.55$, $p < .005$), TUA ($t(18) = -3.96$, $p < .005$) and UTTS ($t(18) = -3.98$, $p < .005$). As mentioned in the previous section, differences on these measures may have been anticipated, given that interactions involving three, as opposed to two, interlocutors may have resulted in reduced opportunity to speak. Therefore these findings were not considered to be unusual. No differences in AGE or the other language measures were found.

Significant differences were also found in UTT.MOT and VOC.MOT – language measures corresponded to the child's first 100 utterances. If the children with siblings present spoke at slower rates, it might be anticipated that the mothers spoke at higher rates during these interactions. However, the differences suggested that mothers in interactions involving more than one child produced more utterances (with sibling present – 214, without sibling present – 126) and used larger vocabularies (221 to 168). As such, as might be predicted as a result of the finding outlined above, these measures were found to be higher for those children who were seen with a sibling present.

SN CHILDREN

In 33% of cases (N = 11), SN children were recorded with one sibling present. In 67% of cases (N = 22) children were seen alone with the mother.

A comparison of language measures for SN children with (Group 1) and without (Group 2) a sibling present was made using independent t-tests. Children without siblings present produced more non-verbal utterances (Group 1 = 5, Group 2 = 11, $t(31) = -2.10$, $p < .05$) and a lower mean MLU score (Group 1 = 3.4, Group 2 = 2.7, $t(31) = 2.28$, $p < .03$) than children with siblings present. This is contrary to the relationship found for all children when they were grouped, and then stratified into groups and compared on this variable (above).

Further analyses were conducted in order to establish that this finding was not the result of differences between the two groups in AGE, hearing level, SEG or age of intervention. No differences were found between the two groups in terms of AGE, SEG, hearing level (BEA or LRA) or age of intervention (AGE.REF, AGE.APP, AGE.DIAG, AGE.FIT). There was also no difference between the two groups in the number of child utterances produced during the interaction. The differences found, therefore, could not be attributed to these factors.

When mothers' language measures were compared for sibling groups 1 and 2 above, differences between group means were observed for a number of the language variables. Mothers interacting with group 2 children (without a sibling present) were found to have higher mean scores on most language measures, including UTTS (Group 1 = 154, Group 2 = 191), WPM (Group 1 = 52, Group 2 = 67), and WDROOTS (Group 1 = 163, Group 2 = 193). However, none of these differences were found to be significant at the 95% significance level.

These results suggest that the SN children who had a sibling present during the session produced higher scores on several of the spoken language measures than those who were seen alone with their mother. This was reversed for PNV, for which children without a sibling present scored significantly higher. By contrast, mothers who interacted alone with the study-child were found to have higher language scores than those mothers seen recorded with the child and one of his/her siblings. This latter observation makes some sense, as the mother would have had to divide her attention between two children during these episodes.

However, the point of interest is that the pattern of results observed for the SN children contrasted with those found for all study-children, and for non-SN children, when stratified according to whether or not a sibling was present during the interaction. The findings suggest that, whereas there appears to be an advantage generally for those children seen without a sibling present, there may be an advantage, in terms of syntax development, to having a sibling present for the SN children in this study.

INFLUENCE OF CHILD AGE ON MOTHERS' LANGUAGE MEASURES

For SN children – child AGE was found to be significantly negatively correlated to TUA.MOT (r = -.41. $p < .05$) and UTTS.MOT (r = -.58, $p < .001$). Thus mothers' rate of speaking was higher for younger children in the study. Similar relationships found between child AGE and language outcomes for non-SN children – MPM.MOT and WPM.MOT (r = -.45, $p < .05$), TUA.MOT (r = -.56, $p < .01$).

Summary

An initial comparison of the subject groups on the language measures revealed a significant difference in proportion of questions and number of utterances produced, which suggested that normal-hearing children scored higher on each of these variables. A significant difference in the proportion of unacknowledged turns during interaction was also found for the mother and the child. This suggested that SN children and parents acknowledged fewer conversational turns appropriately during interaction than those in the other two subject groups.

A comparison of children with and without sensorineural hearing impairment suggested that the hearing-impaired children used smaller vocabularies during the recorded interaction, and there was some indication that the mean length of utterance was lower for this group. A more specific analysis comparing normal-hearing children with a subgroup of the sensorineurally hearing-impaired children indicated that the SN children achieved lower scores on spoken language measures, with these being significant for mean length of utterance and the proportion of questions. The influence of some other factors – socio-economic grouping and sibling presence during the interaction – were investigated. There was some indication that sibling presence influenced language outcomes for the study children and their parents. Both of these factors were explored in more detail as a factor of sensorineural hearing impairment, which modified the results.

7.5 RESULTS (III): EFFECTS OF AGE OF INTERVENTION, HEARING LEVEL AND OTHER FACTORS ON HEARING-IMPAIRED CHILDREN'S LANGUAGE OUTCOMES

7.5.1 AGE OF INTERVENTION

The effects of age of intervention were considered by looking at the language scores derived for all the SN children (SN1 and SN2) in relation to AGE.REF, AGE.APP, AGE.DIAG and AGE.FIT.

The children were stratified into early and late intervention groups for each of the ages of intervention - referral, first appointment, diagnosis and hearing-aid fitting. For each of these variables, children were categorised as having received intervention early (before 12 months = Group 1) or late (at or after 12 months = Group 2). The number of children in each of these groups for each independent age of intervention variable is presented in **Table 7.9a** below.

Table 7.9a – Number of SN children (N = 33) in early (Group 1) and late (Group 2) intervention groups

AGE OF INTERVENTION AT:	GROUP 1 (< 12 MONTHS)	GROUP 2 (> = 12 MONTHS)
Referral	16	17
First appointment	12	21
Diagnosis	10	23
HA Fit	3	30

Independent t-tests were used to compare language outcomes between early and late groups. These analyses revealed no significant differences on any of the child language measures for AGE.REF, AGE.APP, AGE.DIAG or AGE.FIT. However, the small number of subjects in Group 1 for AGE.FIT made any reliable group comparisons difficult.

While no differences were found between the early and late groups in terms of the children's language measures, a significant difference was found for PNV.MOT, which was found to be higher for those children who had been referred early (Group 1 = 2.6, Group 2 = 0.8, $t(31) = 2.64$, $p < .05$), received their first appointment early (Group 1 = 3.1, Group 2 = 0.9, $t(31) = 3.16$, $p < .01$) and been diagnosed early (Group 1 = 3.4, Group 2 = 0.9, $t(31) = 3.45$, $p < .05$). This implies that mothers of children who received early intervention (in terms of referral, appointment and diagnosis) make more use of non-verbal communication strategies than mothers of children who received late intervention.

However, these findings may have been influenced by the children's hearing threshold levels or AGE. Further analyses were thus conducted to address this possibility. No significant difference in hearing threshold level (BEA) was found between early and late intervention groups for AGE.REF, AGE.APP or AGE.DIAG. However, the three children who comprise the early intervention group for AGE.FIT were found to have a mean hearing threshold of 95.7 dB HL. This was significantly higher than the mean threshold for children in the late intervention group for AGE.FIT (mean = 68.6 dB HL, $t(31) = 2.22$, $p < .05$), although this difference has to be interpreted cautiously because of the large difference in group sizes. While this suggests that hearing level may have influenced PNV.MOT for the children in the early AGE.FIT group, it is interesting that the between-group difference in PNV.MOT was found for all the variables *except* AGE.FIT.

Findings may also have been influenced by the AGE of the child at the time of interview. While no significant difference was found in AGE between the early and late referral groups, a significant difference *was* found in AGE between the groups for first appointment and diagnosis ($t(31) = -2.45$ and $- 2.36$, $p < .05$). Those children seen early (before 12 months) were found to be on average 12 months younger for both variables. The difference in AGE may have confounded any differences between the early and late groups that may have been observed in the child language measures and in part account for the difference in PNV.MOT. For example, it might be anticipated that parents of younger hearing-impaired children would make more use of non-verbal utterances during interaction. In addition, children diagnosed late may have produced lower outcome scores comparable to earlier diagnosed, yet younger, children. For the Group 1 children in this example, the age disadvantage may have been compensated by the age-at-diagnosis advantage. This highlights the complexity of interactions which may have influenced outcomes for the hearing-impaired children. The method of analysis employed above is limited in its ability to clarify the effects of various factors of interest. This limitation is addressed below.

PARTIAL CORRELATION ANALYSES

A more appropriate way to consider the relationship between age of intervention and language outcome is to use correlational analyses, which enable the potential effects of AGE to be partialled out if significant.

Controlling for AGE, correlational analyses also revealed no significant relationships between age at referral, first appointment, diagnosis or hearing-aid fitting and any of the children's language measures. The partial correlation coefficients derived from this analysis are presented in **Table 7.10**. The relationship between the independent variables (AGE.REF, AGE.APP and AGE.DIAG) and PNV.MOT, although in the anticipated direction, also became non-significant when AGE was controlled (r = -.20 to -.27).

A significant negative relationship was found between AGE.FIT and BEA (r = -.49, $p < .005$). As a result, analyses were also conducted controlling for the effect of hearing level. This did not change the pattern of relationships found above – i.e. there remained no significant relationship between AGE.FIT and the language measures. Similarly, the exclusion of children with profound hearing impairments (above 95 dB HL) did not change the pattern of results, between age of intervention and language outcomes, for remaining children.

Partial correlations revealed no significant relationships between age of intervention and any of the mothers' language measures.

7.5.2 HEARING THRESHOLD LEVEL

All SN children were stratified into two groups depending on whether hearing impairment was mild-to-moderate (categorised by a loss of between 20 to 70 dB HL – **N = 15**) or severe-to-profound (categorised by a loss of 71 dB HL or more – **N = 18**). No significant difference in AGE was found between those children with mild and moderate hearing impairments (mean AGE = 63 months) and those with severe and profound impairments (mean AGE = 64 months).

Language scores for the two severity groups were then compared using independent t-tests. These revealed significant differences in PNV and VOC ($p < .05$) between the groups.

The mild-to-moderately hearing-impaired children had significantly larger vocabularies than the severe-to-profoundly hearing-impaired children – **VOC.F100**: 103 compared to 85 ($t(31) = 2.12$, $p < .05$) and **VOC.L100**: 112 to 91 ($t(31) = 2.48$, $p < .05$).

The reverse was found for the PNV measure, for which the severe-to-profound group had a significantly higher score – **PNV**: 10 compared to 5 ($t(31) = -2.08$, $p < .05$). The mild-to-moderate group were also found to have a higher MLU (3.2 to 2.7) and lower UTTS.MZ (14 to 17) than the severe-to-profound group, although these differences were not statistically significant.

Interaction of factors

In the previous section, a significant negative relationship was found between hearing level and the age at which children had received a hearing-aid (AGE.FIT). The effect of very late hearing-aid fitting (after 2 years of age) on the different severity groups (mild-to-moderate versus severe-to-profound) was considered in light of this relationship. **Table 7.9b** presents the proportion (and number) of children fitted with a hearing-aid at or after 24 months within each severity banding.

Table 7.9b – proportion (number) of SN children (N = 33) with (i) mild-to-moderate and (ii) severe-to-profound hearing impairments fitted with hearing aids before and after 24 months.

	GROUP 1 Mild-to-moderate (46%)	**GROUP 2** Severe-to-profound (54%)
AGE.FIT < **24 months**	27% (4)	61% (11)
AGE.FIT >= **24 months**	73% (11)	39% (7)

Mean language scores were compared in order to consider the effect of very late (at or after 24 months) hearing-aid fitting on language outcomes as a function of severity group. For group 1 (mild-to-moderate hearing impairments), higher scores on the spoken language measures were not restricted to those who had been fitted before 24 months. Children in group 1 fitted before 24 months appeared to have higher mean scores on the syntax measures – MLU and VOC, while children fitted at or after 24 months were found to have higher rate measure scores (e.g. TUA, UTTS). However, the only significant difference between the AGE.FIT groups for mild-moderate hearing-impaired children was significant for UTTS ($t(13) = -3.03$, $p < .05$).

When the means for children in group 2 (severe-to-profound hearing impairments) were considered, those children fitted at or after 24 months did not appear to have any advantage for any of the spoken language measures. Children fitted before 24 months produced higher scores on the spoken language measures. Of these, TUA ($t(16) = 2.32$, $p < .05$), UTTS ($t(16) = 2.46$, $p < .05$) and WDROOTS ($t(16) = 2.10$, $p < .05$) were significant.

A two-factor between subject analysis of variance, exploring the interaction of late hearing-aid fitting and hearing severity, confirmed that there was a significant interaction between these factors for TUA (F (1, 29) = 7.57, p = .01), UTTS (F (1, 29) = 10.24, p < .005) and WDROOTS (F (1, 29) = 5.76, p < .05).

These results tentatively suggest that late hearing-aid fitting (after two years of age) may have a more detrimental effect for children with severe-to-profound hearing impairments than for those with mild-to-moderate hearing impairments. The effect might be such that for the former group, a wider range of aspects of spoken language may be negatively influenced by late hearing-aid fitting. This may have important implications for neonatal screening programmes as it may be taken to imply that the focus of attention ought to remain on those children with severe-to-profound hearing impairments.

PARTIAL CORRELATIONS

Correlation analyses, controlling for AGE, confirmed a significant negative relationship between hearing threshold level (BEA) and VOC.L100 (r = -.41, df = 30, p <.05). And a significant positive relationship with PNV was found (r = .35, df = 30, p < .05). These are presented in **Table 7.10.** This suggests that increased hearing thresholds correspond to lower vocabulary scores and greater use of non-verbal utterances during interaction. Negative, but non-significant, correlations were also found with MLU (first 100 utterances (r = -.21) and wdroots (r = -.23).

Summary

Hearing threshold level was found to be significantly related to vocabulary and the proportion of non-verbal utterances produced by the children. The relationships

Table 7.10 – Partial correlations found between the language measures and (i) age of intervention (i.e. age of referral, 1st appointment, diagnosis and hearing aid fitting) and (ii) hearing threshold in the better ear, controlling for age at interview for all SN children. The arcsin root transformations of PNV and PQU are also used.

LANGUAGE METRIC	AGE AT (MONTHS):				HEARING LEVEL
	REFERRAL	FIRST APP	DIAGNOSIS	FIT	
MLU.F100	-0.18	-0.19	-0.15	+0.09	-0.21
TUA	-0.08	-0.04	-0.01	-0.10	+0.07
WPM	-0.10	-0.06	-0.01	+0.11	-0.17
MPM	-0.15	-0.12	-0.05	+0.05	-0.15
PNV	-0.09	-0.11	-0.17	-0.01	+0.35*
PNV.ASIN	-0.19	-0.21	-0.25	-0.15	+0.32
PQ	-0.17	-0.16	-0.17	-0.20	+0.28
PQ.ASIN	-0.17	-0.16	-0.19	-0.22	+0.30
VOC.F100	+0.11	+0.09	+0.09	+0.20	-0.32
VOC.L100	+0.24	+0.23	+0.22	+0.13	-0.41*

* $p < 0.05$, N = 33, df = 30

In comparison to the first study (see Chapter Five), there are no significant negative correlations between age of intervention and the language measures. In addition, there is the anomaly that age at hearing-aid fitting is positively correlated with four of the language measures, though not significantly, while vocabulary appears to be positively related to the AGE.REF, AGE.APP and AGE.DIAG. Hearing level, also in contrast to the first study, is negatively correlated with most of the language measures. These partial correlations are significant for VOC and PNV.

suggested that the children with mild-to-moderate hearing impairments had larger vocabularies and produced fewer non-verbal utterances in comparison to those with severe-to-profound impairments. Further analyses also suggested that there was a significant interaction between hearing severity and age at hearing-aid fitting, such that children with severe-to-profound hearing impairments may be more disadvantaged by very late (after two years of age) hearing-aid fitting than their mild-to-moderately hearing-impaired peers. The interactive effect of late hearing-aid fitting and higher hearing thresholds related to significantly lower scores on two measures of general language productiveness (TUA and UTTS) and WDROOTS.

7.5.3 MULTIPLE REGRESSION ANALYSES

While the above analyses highlight some patterns and relationships in the data, they are limited in that they do not take into consideration the unique contribution of a particular independent or predictor variable while holding constant, or partialling out, the effects of other independent variables. Regression analysis permits this limitation to be addressed.

In the partial correlational analyses, AGE was statistically controlled, thus allowing for its effect on the outcome variables of interest. However, this was not used to simultaneously consider the size of the influence of other variables, such as the age of intervention variables or SEG.

Using multiple regression analyses, it is possible to consider the combined effect of a number of independent variables (or predictors) on the dependent variable (or criterion). The resultant model also distinguishes those variables which are significant predictors of the dependent variable and provides estimates, in the form of partial regression coefficients, of the influence of these on the dependent variable of interest. The partial regression coefficients permit predictions to be made for the value of a particular dependent variable from independent factors for the given subject sample.

Earlier results sections highlighted some relationships between the dependent and independent variables for hearing-impaired children, but also revealed the potential complexities of interactions between the independent variables. Multiple regression potentially allows for a fuller exploration of the effects of a number of variables on outcomes for these children, which is the focus of this thesis. However, it is also important to note that important psychological effects may not necessarily be statistically significant, because of a lack of power due to limited subject numbers.

In summary, direct multiple regression was chosen as it enabled the individual and combined effects of the independent variables to be examined. This was considered an appropriate method by which to look at the effects of a number of factors such as AGE, age of intervention, hearing level, SEG and mothers' language, on the hearing-impaired (SN) children's language measures.

Direct regression included the following variables as predictors of language outcomes for the SN children: AGE, age at referral (AGE.REF), age at diagnosis (AGE.DIAG), age at hearing-aid fitting (AGE.FIT), hearing threshold level (BEA), and socio-economic group (SEG). Age at first appointment (AGE.APP) was excluded from the model because of its extremely high correlation with age at referral ($r = .99$, $p < .005$) (see **Table 7.11**).

Table 7.11 – Correlations between ages of intervention and hearing level for all SN children. The correlations below illustrate the high degree of collinearity between age of intervention variables – AGE.REF, AGE.APP, AGE.DIAG and AGE.FIT, but in particular between AGE.APP and AGE.FIT. Correlation between hearing level (BEA) and AGE.FIT is also significant.

Age at:	Hearing Level	Fit	Diagnosis	First App	Referral
Interview	.02	.31	.25	.31	.28
Referral	-.22	.67*	.95*	.99*	
First App	-.26	.70*	.96*		
Diagnosis	-.35	.78*			
Fit	-.49*				

* p < .05, N = 33

The language produced by parents during the recorded episode of interaction was also incorporated as a potential influencing factor. Therefore, language measures derived from the mothers who took part in the recorded interactions were included as possible predictors. Patterns of collinearity between these measures were explored and taken into consideration. This led to the following measures of mothers' language being incorporated: MLU.MOT, VOC.MOT, WPM.MOT, PNV.MOT and PQU.MOT. The following parental language measures were excluded from analyses in order to minimise collinearity: MPM.MOT, TUA.MOT, WDROOTS.MOT and UTTS.MOT. For all measures of mothers' language included in the analyses, it was established that there were no differences between groups SN1 and SN2. Mean values for mothers' language scores are presented in **Table 7.12**.

Table 7.12 – Means and standard deviations for mothers' language measures for SN1 and SN2 groups.

	UTTS (MOT)	MLU (MOT)	VOC (MOT)*	UTTS.MZ (MOT)	WDROOTS (MOT)	TUA (MOT)	WPM (MOT)	PQU (MOT)	PNV (MOT)
SN1 MEAN (S.D.)	200 (84)	4.6 (.96)	133 (36)	3.3 (3.1)	195 (70)	17 (4)	70 (16)	38 (13)	2 (2)
SN2 MEAN (S.D.)	161 (59)	4.8 (.89)	134 (21)	5.4 (3.8)	172 (42)	13 (6)	55 (28)	34 (10)	2 (3)
COMBINED MEAN	179 (73)	4.74 (.92)	133 (29)	4.42 (3.6)	183 (57)	14.6 (5.4)	62 (24)	36 (12)	1.67 (2.2)

Comparison of the above means for sn1 and sn2 groups revealed significant differences in TUA.MOT ($t(31) = 2.69$, $p = .01$) only.

The partial regression coefficients derived from the multiple regression analyses are presented in **Table 7.13**. The Table details the proportion of variance accounted for by the predictors for the dependent variable (R^2), and the significance of the combined effect of the predictors (Sig. F). Individual variables are highlighted when their contribution to the model is significant ($p < .05$).

DIRECT REGRESSION ANALYSES

Table 7.13 – SN Children (N = 33)

Partial regression coefficients derived from direct multiple regression analyses. Independent variables (predictors) are age, age of intervention (represented by the age at referral, diagnosis and at hearing-aid fitting), hearing severity (BEA), socio-economic grouping and mothers' language (MLU, VOC, WPM, PQU, and PQU – the arcsin root transformation of PQU and PNV was used). Dependent variables (criteria) are children's spoken language measures. Mothers' language measures are chosen so that all categories of language measure (syntax, rate and interaction) are represented while any effects of multi-collinearity, due to high co-variance between the independent variables, is minimised. Therefore the following measures have been omitted from the model – TUA, MPM and WDROOTS. All figures are to 3 decimal places.

All mothers' language measures are derived from corpus of first 100-child-utterances.

Table 7.13 – SN Children (N = 33)

Syntax	Predictors (IV) β (beta)														
Criterion (DV)	**Constant**	**AGE**	**AGE.REF**	**AGE.DIAG**	**AGE.FIT**	**BEA**	**SEG**	**MLU (MOT)**	**VOC (MOT)**	**WPM (MOT)**	**PQU (MOT)**	**PNV (MOT)**	**Signif. F**	**R^2**	**R^2 Adj**
MLU.F100[1]	.993	.011 (.175)	-.042* (-.725)	.026 (.414)	.023 (.365)	-.005 (-.126)	-.428* (-.244)	.774** (.798)	.001 (.025)	-.015** (-.395)	-1.398 (-.198)	-1.814 (-.185)	**.0001**	**.84**	.76
MLU.COM[2]	-.447	.011 (.165)	-.057* (-.930)	.041 (.626)	.031* (.474)	.001 (.006)	-.563** (-.305)	.818** (.803)	.001 (.023)	-.013* (-.337)	-.620 (-.084)	.115 (.011)	**.0001**	**.87**	**.80**
MLU.TOT[3]	-.271	.012 (.187)	-.059* (-.942)	.041 (.644)	.028* (.437)	.001 (.010)	-.597** (-.337)	.726** (.740)	.002 (.066)	-.011* (-.303)	.369 (.052)	385 (.039)	**.0001**	**.86**	.79
VOC	-16.595	.482 (.266)	-.899 (-.538)	.521 (.292)	.522 (.291)	-.187 (-.156)	-5.561 (-.110)	11.156 (.401)	.340 (.380)	-.290 (-.276)	16.808 (.083)	2.757 (.010)	**.002**	**.70**	.55
VOC.L100	-.192	.608* (.337)	-.286 (-.172)	.725 (.409)	-.124 (-.069)	-.411* (-.346)	-2.711 (-.054)	12.129* (.439)	.198 (.223)	-.131 (-.125)	6.177 (.031)	77.832 (.279)	**.0003**	**.75**	.62
SIGNS	-4.442	.266 (.403)	.080 (.132)	.030 (.047)	-.180 (-.276)	.111 (.255)	-.160 (-.009)	-2.474 (-.244)	-.101 (-.311)	.048 (.126)	11.514 (.156)	11.599 (.114)	.30 (n.s.)	.40	.09
WDROOTS	-180.651	1.196 (.284)	-2.885 (-.745)	3.017 (.730)	-.084 (-.020)	.035 (.013)	20.856 (.179)	-9.638 (-.150)	.995 (.480)	.009 (.004)	211.585 (.451)	140.011 (.215)	.39 (n.s.)	.37	.04

* $p < .05$, ** $p < .005$

[1] MLU derived from first 100 utterances
[2] MLU derived from complete and intelligible utterances only (whole transcript)
[3] MLU derived from total utterances (whole transcript)

Table 7.13 (continued) – SN Children (N = 33)

Rate & Interact	Predictors (IV) β (beta)														
Criterion (DV)	**Constant**	**AGE**	**AGE.REF**	**AGE.DIAG**	**AGE.FIT**	**BEA**	**SEG**	**MLU (MOT)**	**VOC (MOT)**	**WPM (MOT)**	**PQU (MOT)**	**PNV (MOT)**	**Signif. F**	**R^2**	**R^2 Adj**
WPM	-44.030*	.311* (.473)	-.736* (-1.217)	.608 (.942)	.230 (.355)	.107 (.248)	-1.978 (-.109)	-1.323 (-.132)	.073 (.225)	.036 (.094)	47.448* (.647)	21.639 (.213)	**.03**	**.57**	**.34**
MPM	-45.350*	.346* (.486)	-.763 (-1.164)	.596 (.851)	.221 (.315)	.106 (.226)	-1.672 (-.085)	-1.662 (-.152)	.085 (.242)	.055 (.134)	49.056* .617	24.577 (.223)	**.05**	**.54**	**.30**
TUA	-2.187	.082* (.372)	-.147 (-.723)	.163 (.750)	-.053 (-.240)	.036 (.248)	1.467 (.239)	-2.237* (-.660)	.010 (.092)	.031 (.246)	13.915* (.563)	6.000 (.175)	**.02**	**.60**	**.38**
UTTS.MZ	-71.049*	.144 (.163)	-.386 (-.475)	.349 (.402)	.343 (.393)	.226 (.390)	.440 (.018)	4.479 (.331)	.026 (.061)	-.007 (-.014)	37.356 (.379)	21.411 (.157)	.28 (n.s.)	.41	.10
UTTS	-233.314	.493 (.074)	-9.551* (-1.555)	10.318* (1.573)	-.680 (-.103)	1.601 (.365)	65.233 (.353)	-61.997* (-.607)	1.400 (.426)	-.420 (-.109)	455.72* (.612)	365.554* (.354)	**.02**	**.59**	**.37**
PQU	.322	.002 (.208)	-.007 (-.663)	.006 (-571)	.001 (.052)	.003 (.372)	-.030 (-.102)	.057 (.347)	.000 (.012)	-.001 (-.085)	.077 (.065)	-.015 (-.009)	.64 (n.s.)	.30	-.08
PNV	.125	.000 (.021)	.006 (.705)	-.008 (-.906)	.001 (.082)	.002 (.270)	.105 (.402)	-.023 (-.155)	.001 (.110)	.003* (.482)	-.344 (-.326)	.147 (.101)	.17 (n.s.)	.46	.18

* p < .05, ** p < .005

The independent variables combined accounted significantly for between 30% and 80% (adjusted R^2) of the variance for several of the child language measures. These were: MLU, VOC, MPM, WPM, TUA, and UTTS.

Mean length of utterance (MLU)

For the child's mean length of utterance (MLU.F100, MLU.COM, and MLU.TOT), a significant proportion of variance was accounted for by the independent variables combined (Adjusted R^2 = .76, .80 and .79 respectively).

Of the individual predictors, the most important were the mothers' MLU and WPM. The results suggest that higher MLU.MOT corresponds to higher child MLU – the regression coefficient indicates that a one morpheme increase in MLU.MOT corresponds to an increase of 0.77 in the child's MLU, all other variables being held constant.

While the influence of MLU was positive, the influence of WPM was negative. This corresponds to findings reported earlier in this chapter which suggest that the mothers' rate of speaking seemed to decline in relation to the complexity of the language being produced by the child. This contrasted to measures corresponding to syntax, which seemed to increase in association with the child's performance in these areas.

Socio-economic grouping and age at referral were also found to make significant individual contributions to MLU. The regression coefficients suggest that a 10 month decrease in age at referral corresponds to an increase of 0.5 in child's MLU score, while a similar increase in MLU can be achieved by a move from SEG-categories 4-5 to SEG category 1-3.

In addition to the above predictors (MLU.MOT, WPM.MOT, SEG and AGE.REF), age at hearing-aid fitting (AGE.FIT) was also found to exert a significant effect on MLU.COM. Its influence, however, is such that a *delay* of 10 months in hearing-aid fitting would seem to correspond to an increase in the child's MLU score. This might be considered somewhat of an anomaly, but probably relates to the interaction between hearing level, age and age at hearing-aid fitting. This was such that children with mild-to-moderate hearing impairments were fitted later than those with severe-to-profound hearing impairments. In addition, it might be argued that those children who waited longer for their hearing impairments were also of less concern.

However, the positive influence of AGE.FIT on this variable is not quite as large as the negative influence should age at referral be delayed. The model suggests that a corresponding delay of 10 months in age at referral may result in a decrease of over 0.5 in the child's MLU score.

Morphemes per minute (MPM)

Predictors were found to account for less of the overall variance (R^2 = 54%, adjusted R^2 = 30%) for the measure of morphemes per minute. Age at referral was found to influence MPM negatively, implying, as for MLU above, that earlier referral corresponds to higher performance on this measure. The AGE of the child was also found to be a significant predictor for this variable, as might have been anticipated from the correlational analyses presented earlier in the chapter. The results suggest that a 10-month earlier referral corresponds to a 20 month increase in AGE, in terms of its impact on the child's MPM score. In relation to the mothers' language, the proportion of mothers' questions was found to significantly influence the MPM measure.

Words per Minute (WPM)

The words per minute measure was found to be very similar to MPM. Age, age at referral and PQU.MOT were also significant predictors for this variable, with a 10 month delay in referral corresponding to an increase of 7 in the child's WPM.

Total utterance attempts per minute (TUA)

Age and the proportion of questions asked by the mother (PQU.MOT) make the most significant individual contributions to the TUA measure. The partial regression coefficients suggest that a 10-month increase in AGE corresponds to an increase of 0.8 in TUA, and the mother's PQU was also found to be an important positive predictor of TUA. The implies that if the mothers' conversation contains a higher proportion of questions, the child's rate of speaking, as measured by total utterance attempts per minute, increase.

Vocabulary (VOC)

The combined effect of the predictors account for over 50% of the variance. Age at referral and hearing level were found to exert a negative influence on vocabulary within the regression equation. This is the only language measure that hearing level was found to significantly influence independently – the model suggests that a 10 dB increase in hearing level corresponds to a reduction of four words in the child's vocabulary, while a 10 month increase in AGE corresponds to a six word improvement in the vocabulary score.

Number of utterances produced by child (UTTS)

AGE.REF, AGE.DIAG, SEG, MLU.MOT, PNV.MOT and PQU.MOT were found to be important individual predictors for the number of utterances produced by the child during the recorded episode. Age at referral and age at diagnosis emerged as the most important predictors, but would appear to influence UTTS in contradictory ways. The results are such that they suggest that if referral is delayed by 10 months, the number of child utterances decreases by 96. Early referral thus corresponds to greater general productiveness in the child's use of spoken language. However, counter-intuitively, the results also suggest that a corresponding 10 month delay in age at diagnosis may result in an *increase* of just over 100 utterances. This is difficult to explain and may have emerged for a number of reasons which are explored in more detail in the discussion.

Increases in the mothers' non-verbal language (PNV.MOT) and questioning behaviour (PQU.MOT) also corresponded significantly to the number of utterances produced by the child. This may be because PNV.MOT, and certainly PQU.MOT, serve to encourage hearing-impaired children's conversational participation in a way that increased length of utterance for the mother does not – MLU.MOT is correlated negatively to the child's number of utterances within the equation.

Proportion of non-verbal utterances (PNV)

In combination, the predictors entered were not found to account for much of this variable, although there is some suggestion that the rate of mothers' speaking (WPM.MOT) may be an important individual predictor.

The combined effect of the independent variables entered into the multiple regression analyses were found to be insignificant for the following measures: SIGNS, WDROOTS, UTTS.MZ, PQU and PNV.

Proportion of questions (PQU)

The predictors entered were not found to account for the PQU to any significant degree. This contrasts with findings from the first study, where age at referral and the age of the child successfully accounted for a significant proportion of the variance of PQU.

Summary

The independent variables – age, age of intervention (referral, diagnosis and fit), hearing level, SEG, and a range of measures representing the mothers' language (MLU, VOC, WPM, PQU and PNV) – emerged from the multiple regression analyses as having a significant combined effect on a number of the child's spoken language outcomes. These were the mean length of utterance, vocabulary, words per minute, total utterance attempts per minute and overall number of utterances produced by the child. The predictors could not adequately account for the variability in the number of different word roots, signs and utterances in mazes, or for the proportion of questions and non-verbal utterances produced by the child.

The results also confirmed the influence of certain individual predictors on the child language measures, as had been suggested by analyses presented in earlier sections of this chapter. For instance, hearing severity was found to significantly influence the vocabulary of the child.

Aspects of the mothers' language, such as MLU and WPM, were found to be important individual predictors for some of the child language measures, notably the child's MLU. However these two measures seemed to have opposite effects to one another on the dependent variables. In addition, there are problems with incorporating maternal language measures derived from the same interaction as the children's language measures in regression model (Richards, 1994). Thus, results relating them to one another need to be interpreted cautiously.

In addition, age of intervention – age at referral and diagnosis – were variably found to exert significant individual influences on the variables MLU, WPM and UTTS. There was some indication that earlier referral may be related to better outcomes in the domain of spoken language for hearing-impaired children.

These results are discussed in the next section.

7.6 DISCUSSION

7.6.1 OVERVIEW OF FINDINGS

When the language measures were examined by group, inconsistent patterns emerged from the data. Although the groups were not found to statistically differ in age, language scores for the normal-hearing and conductive children were higher on many of the variables, particularly those related to syntax (MLU and vocabulary). By contrast, sensorineurally hearing-impaired children produced higher proportions of non-verbal utterances during the recorded interactions and seemed to be speaking faster than children in the other two groups. This latter finding may have been confounded by the higher number of overall utterances recorded for SN children.

However, statistical comparisons of subject-group performances revealed few significant differences on the language measures. For most of the language measures, SN children were found to have group means below those of normal-hearing children, although few of these differed significantly. The results did suggest there was a significant difference in the use of vocabulary between SN children and non-SN children. This implies that the presence of a sensorineural hearing loss may have resulted in the use of less extensive vocabularies for the children in the sample. The results also suggested that, in comparison to the COND and CONT groups, the SN children and their parents acknowledged fewer turns appropriately during interaction. This implies that the presence of a hearing impairment may have interfered with the smooth exchange of conversational turn-taking for interlocutors in this group.

A variety of factors contributed to make interpretations of group differences particularly difficult in this study. One of these factors may have been group composition. For instance, comparisons between SN and non-SN groups was difficult, as the non-SN group contained a subset of children (COND) with history of conductive hearing impairment. This group was particularly atypical in that a number of independent variables could be identified which may have influenced the dependent variables of interest – the spoken language outcomes.

The COND group was small in number, comprising of nine children, most of whom had a history of being in NICU after birth. This made them quite distinct from the other subject groups. In four cases, these children had twins, for whom data was also collected. There is some evidence to suggest that the language of twins differs from that of singletons, although several researchers have questioned conclusions drawn from these studies (Bishop, 1992). Apart from the direct potential influence of twin status on language production, the recorded sessions involving twins invariably included them both. Thus, few of these children were seen alone with the major caregiver; they were seen with the major caregiver *and* their twin sibling. It was shown in section 7.4.1 that this may have influenced the productivity of language during the interaction for the parents and children involved. This bias in interaction context may have provided a range of language measures that cannot be reliably compared with those derived for children in other groups. While the recordings derived for these twinned children may provide an interesting pool of data for examination, this was not the purpose of the research presented here.

In addition to the factors identified above, skewed SEG (only SEGs 3, 4 and 5 were represented) and a particularly low uptake rate were observed amongst families in the COND group approached to take part in the study. These factors may also have contributed to the pattern of results observed for these children. Therefore, any comparisons with, or conclusions about, this group need to be tentative as a consequence. The inconsistent results found for the COND group of children may be reflective of the combined influence of these factors. For instance, none of the language measures for this group were found to be related to AGE.

7.6.2 HEARING SEVERITY

When a subset of the SN children were compared to normal-hearing children a clearer pattern of differences emerged which were suggestive of mild language delays for the hearing-impaired children when compared with their normal-hearing peers. This finding would not be unusual and would agree with a number of studies which suggest that the spoken language of hearing-impaired children may be delayed in comparison to that of hearing children (for example Moeller et al., 1986 – see Chapter Two).

While there is inconsistency in findings relating hearing severity to language production, the results presented in this study suggest that hearing level may account for differences observed in the language scores between hearing-impaired and normal-hearing children. For the hearing-impaired children, higher hearing threshold level was found to be significantly related to poorer outcomes in vocabulary and better outcomes in the proportion of non-verbal utterances used (age was statistically controlled). As might be anticipated, this implied that the more severely hearing-impaired children were using more restrictive vocabularies during the interaction and relied on a higher proportion of non-verbal acts to support communication. The IHR-McCormick Toytest also confirmed that there was a significant difference in functional hearing level at the time of the visit between hearing-impaired and normal-hearing children.

7.6.3 AGE OF INTERVENTION

The partial correlations, allowing for the age of the child, revealed no relationship between age of intervention and the language measures. This implies that the promptness of detection did not directly influence his/her spoken language production skills. This finding contrasts with findings from the first study, where age of intervention, particularly age at referral, was found to be significantly related to increased outcomes on several language measures – for example, words per minute and the proportion of questions asked (see Figure 5.12).

When age of intervention was considered in combination with a range of other factors in the regression analyses, it was found to correspond to several of the language measures (MLU, VOC, WPM). In particular, age at referral and age at hearing-aid fitting appeared to act as significant individual predictors for several measures. However, the patterns of association were not consistent and may be interpreted as somewhat anomalous. One interpretation of the results is that fitting hearing-aids later may result in *better* outcomes for children on aspects of their language.

A possible explanation for the anomalous findings is that the effect produced by the regression analysis is the product of a complex interaction between a number of factors. Alternatively, this might be explained by the relationships found earlier between hearing level and age at hearing-aid fitting. Age at hearing-aid fitting was found to be significantly related to hearing level, such that children with severe-to-profound impairments tended to be fitted earlier (six months on average) than those with mild-to-moderate impairments. At the start of this thesis, it was stated that the age of detection has been lowered for children with severe-to-profound hearing impairments. Thus the relationship between age at hearing-aid fitting and hearing threshold level may be a reflection of this trend. In addition, there was some evidence that late aiding (after 24 months) may have been more detrimental for those children with severe-to-profound hearing impairments.

Age at referral was found to be a significant individual predictor of MLU, the words per minute and the overall number of utterances produced. Here, the direction of influence was as might be anticipated – i.e. a lower age at referral results in improved performance on these measures.

Interestingly, hearing level was not found to be significantly related to the other age of intervention variables – age at referral, first appointment or diagnosis. This suggests that for this sample, the largest discrepancy between children with mild-to-moderate and those with severe-to-profound losses may be in the delay between referral/diagnosis and hearing-aid fitting.

A moderately hearing-impaired child was found to have the largest delay between referral and fitting. However, children with mild-to-moderate hearing impairments did not have a monopoly over prolonged delays within the group. Eight of the hearing-impaired children in the sample had delays between referral and fit of more than 12 months. Of these, three children had severe hearing impairments, while the other five had mild or moderate hearing impairments. There are three instances of hearing-aid fitting being delayed for more than 30 months (31, 34 and 46 months) – in all instances these are children with mild or moderate hearing impairments. However, it should be noted that 18 children in the sample (55%) waited no longer than six months after referral for a hearing-aid. But the question remains, when does a delay become detrimental to a child's developmental progress? Few would challenge the inappropriateness of delays in excess of a year, but six month delays may be equally detrimental to the child's development. As discussed in Chapter Five, hearing-aid fitting may be delayed for a number of reasons. This might include the presence of complicating middle ear disorder, failure to attend appointments or an unwillingness on the part of parents to accept the confirmation of their child's hearing impairment. In addition, clinicians may take language performance into consideration such that children with 'better' language are inadvertently fitted later. For this sample of children, no clear relationship between the delay in hearing-aid fitting and any of the language measures emerged. However, a relationship between age at referral and the language measures is evident, possible explanations for which are considered below.

In summary, the relationship between hearing level and age of intervention, particularly hearing-aid fitting, may have served to confound observed relationships between the language measures and age of intervention. The results indicate that children in the study with severe-to-profound hearing impairments tended to be fitted with aids earlier than children with mild-to-moderate hearing impairments. And later hearing-aid fitting was associated with better performance on some of the language measures. These factors make the relationship between age at fitting and spoken language difficult to evaluate.

Furthermore, we may be able to clarify the findings by considering why mild-to-moderately hearing-impaired children receive hearing-aids later. It was earlier argued (see Chapter Five) that some children with mild-to-moderate hearing impairments may only be detected when noticeable delays in language set in. These children may have been functioning well *despite* the presence of a hearing loss and constitute a subgroup of high performers – hearing-impaired children who may have had excellent language skills had it not been for their hearing impairments. As such, these high performers may be able to compensate for their hearing impairment and go undetected until they need to interact in a wider range of social situations. The presence of such children in the study may have resulted in anomalous findings between age of intervention and the language measures – late fitting of hearing-aids may then become associated with better language performance.

It is possible that subgroups of high and low (language) performers may be found within populations of mild-to-moderately hearing-impaired children. As a result, the challenge of future research will be to evaluate outcomes for hearing-impaired children allowing for the potential influence of variables such as these. This speculation may in part explain the inconsistency in findings reported in the literature on outcomes for these children. The inclusion of various undefined sub-populations of hearing-impaired children may also account for why findings from different studies are often difficult to compare.

The more reliable influence to consider within the regression analyses may be the influence of age at referral on some of the child's language measures. This implied that earlier referral, allowing for the other independent variables in the regression model, may result in increased outcomes in general syntax and language productiveness. This seems to consolidate findings from the first study. As discussed in that study, age at referral may relate to some element of the parents' attitude towards the hearing impairment. As was seen from the responses to questions presented in Chapter Six, many parents had sought a referral for their child long before they had actually received one. In many cases, parents would face delays of six months on average following referral before the child received formal intervention in the form of diagnosis and hearing-aids. In many instances, this delay was considerably longer. It is possible that the process of referral marks an important shift in attitude for parents who suspect that their child may have a hearing impairment. In study one, a similar explanation was proffered in light of the significant influence of earlier referral on some of the language measures for that sample of children. In this study, age at referral seems to be a potentially important factor when considered in combination with other factors such as age and hearing level. This may have important implications for neonatal screening, which would predictably lower the age of referral for a significant proportion of hearing-impaired children.

7.6.4 Socio-economic grouping

Socio-economic grouping also emerged as a factor that may influence outcomes for hearing-impaired children. Findings suggested that hearing-impaired children in upper SEG families (seg-1, and 2) had some advantage in their performance in comparison to children from families in SEG 3, 4 and 5. For the SN children alone, the SEG group to which a child's family belonged seemed to influence the MLU and the TUA measures. Children belonging to lower SEG categories seemed to perform better on the MLU measure and worse on the TUA measure. These results are similar to those found in the first study. However, there are complexities in using SEG as a measure and it was suggested that the influence of SEG on language outcomes has to be interpreted cautiously. It is difficult to interpret what exactly SEG corresponds to, and it may well represent a myriad of variables which may influence development.

7.6.5 Mothers' language

The regression analyses also revealed the mothers' language as an important predictor for some of the child language measures (MLU, vocabulary and the rate measures such as WPM). This suggests that if the mother uses longer utterances and has a larger vocabulary this may lead to longer utterances and a larger vocabulary for the child. For the rate measures, however, the relationship between mother- and child-language outcomes was negative. Thus, a lower MPM.MOT – a slower rate of language production from the mother – would seem to correspond to 'better' outcomes in language syntax (e.g. MLU) for the child. There would seem to be a relationship between the language the child perceives during the interaction and the language he or she produces.

There is good evidence that for hearing-impaired children parents modify their language depending on how the child talks, generating a feedback loop. As a result of the methods of data collection and analysis, it is impossible to determine the direction of influence in any associations observed between the factors. Therefore, although the results suggest that there is some association between mother and child's language production, it is difficult to infer how the association arises and who is influencing whom. The observed relationship may be explained by another factor which exerts its influence on both the child's and the mother's language in dyadic interactions of this sort. However, where the speakers are regularly engaged in conversation with one another, as may be the case with a major care-giver and a hearing-impaired child, the pattern of influence may become more complex. The relationship between what one speaker produces in response to what is perceived will inevitably become to some degree reciprocal. This needs to be carefully accounted for within any analysis that seeks to evaluate the influence of child-directed language on the language of the child.

There would appear to be a complex interaction of influences on a hearing-impaired child's spoken language. The child's hearing impairment, age of intervention, mother's language and interaction style, and socio-economic variables, combine to account for significant proportions of elements of language production.

7.6.6 Reliability of language measures

For the purposes of this study, a range of language measures were used to represent spoken language production. Many of these were standard measures that have been used frequently in a number of studies on child language (See Chapter Three). However, one potential limitation of the study may have related to the measures used to represent spoken language production. There was some indication in the results that MLU, despite reports of its limited reliability when used with populations above four years of age (Scarborough et al., 1991), proved a useful indicator of basic syntax for the children in the study. At the start of the study, it was anticipated that MLU may fail to differentiate between individual performances and that many children, particularly in the normal-hearing group, may be found to asymptote in their scores, thus making group comparisons difficult. The measure may have been found to be insufficiently sensitive to differentiate between individuals sufficiently to yield any data of interest, particularly in the older age range. However, MLU proved to be highly correlated to age for the children in the study, and differences in MLU were highlighted between normal-hearing and hearing-impaired children.

The chosen language measures provided indicators of only peripheral elements of language – basic syntax, general productiveness, questioning behaviour and use of non-verbal utterances. As such, there are several indicators of interaction between the participants which could have been explored in more depth. These include the relevancy of turns taken and a more detailed categorisation of both verbal and non-verbal utterances (demands, questions, closed or open requests, etc.).

7.6.7 POTENTIAL FOR LANGUAGE DEVELOPMENT

The indicators of spoken language production considered provided a snapshot of children interacting with their parents. The shortcoming of this approach is that little can be determined about the children's development of language, or their potential for development. It would be interesting to evaluate how the factors of influence considered in this study may influence language outcomes over time. This emphasises the importance for more sophisticated, large-scale prospective studies which may enable children's language and communication to be regularly sampled and analysed. Only then might clearer patterns of influence emerge and the particular importance of specific factors and interventions highlighted. The centralisation of information about hearing-impaired children and services provided by districts may enable studies of this kind to be conducted feasibly in the future.

There were several children with profound hearing impairments in the study sample who perform within the upper percentile on several of the language measures despite the severity of their hearing-impairments (AB, CC, JH, RW – see audiological profiles in Appendix for more detailed overview of hearing-impairments). Closer examination of children such as these may indicate which factors are of particular benefit for expressive language and communication development. The data available reveal no clear relationships between these children's ages of intervention and spoken language. One factor that is shared by all these children is their attendance at private schools. More recent assessments involving these profoundly hearing-impaired children confirm that their expressive language continues to be good despite the severity of their hearing impairments. It would be interesting to consider how performances compare with children similarly impaired, detected and aided who attend the state school system. Despite attempts to ascertain details of interventions received by the children from Educational Services, these were not forthcoming. This meant that important interventions, which need to be considered within any evaluation of intervention, could not be fully reviewed.

7.7 CHAPTER SUMMARY

The second study aimed to investigate the influence of a range of factors including hearing level, age of intervention and parental language on the spoken language of a group of hearing-impaired children. Children with hearing-impairments ranging from mild to profound were included and language samples derived for children in the first study were re-analysed for consideration. Data on two other groups of children were also collected for comparison – children with conductive hearing-impairments and children with normal-hearing.

Inconsistent relationships were found for each group of children when their language outcomes were correlated with age. This suggested that there may have been other factors influencing language performance. These were investigated in more detail. Differences between normal hearing and hearing-impaired children were found for several of the spoken language measures. These differences were statistically significant for two measures, suggesting that hearing-impaired children used smaller vocabularies and had lower MLU scores than the hearing children. In addition, the hearing-impaired children and their mothers appeared to acknowledge fewer turns appropriately during conversation than non-hearing-impaired children and their mothers.

The influences of hearing severity and age of intervention were considered for the hearing-impaired children. Hearing severity was found to be significantly related to one of the spoken language measures and age of intervention appeared to influence some elements of the children's spoken language, although its influence was not clear. Multiple regression analyses enabled the combined effects of a range of factors and the size of their influence on the children's language to be considered. These suggested that, for the hearing-impaired children, the age and hearing level of the child, age of intervention, socio-economic grouping and elements of the mother's language may account for significant proportions of the variability for the measures of vocabulary, mean length of utterance, and measures related to the child's rate of speaking (e.g. WPM and UTTS).

The relationship between age at hearing-aid fitting and language outcome was confounded by the fact that children with mild-to-moderate hearing impairments received their hearing-aids later, on average, than those with severe-to-profound hearing impairments. It was also suggested that the age at hearing-aid fitting may itself have been influenced by the dependent variable of interest – spoken language, such that 'better' language may have inadvertently resulted in later aiding.

By contrast, the 'age at referral' was found to influence language outcomes in certain domains, including the mean length of utterance and words per minute. The direction of influence was such that earlier referral corresponded to 'better' language outcomes. It was also suggested that patterns of interaction between age of intervention and spoken language outcomes may be different for mild-to-moderate hearing-impaired children in comparison to children with severe-to-profound hearing impairments. Findings tentatively suggested that late hearing-aid fitting may be more detrimental for children with severe-to-profound hearing loss, which may have implications for the prioritisation of services. Finally, some of the limitations of the study were considered.

CHAPTER SEVEN FIGURES

Language Measures by Age - all subjects

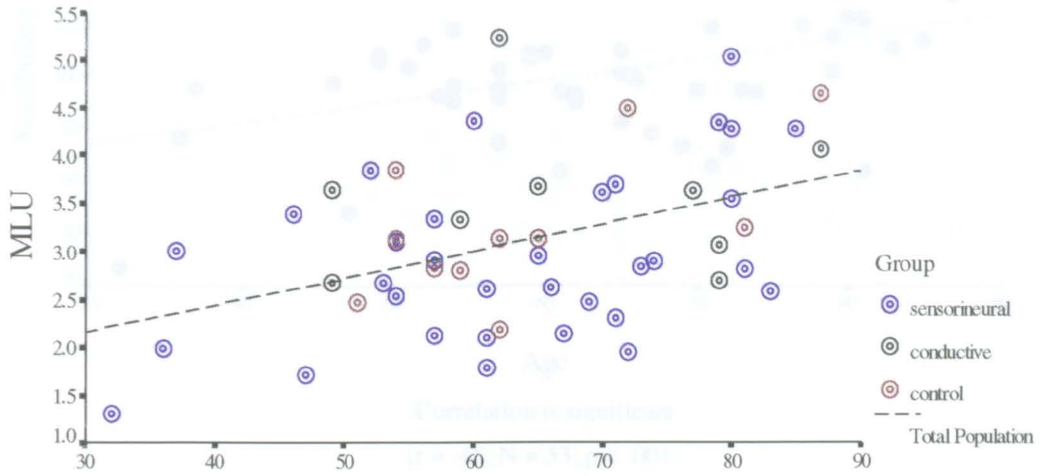
Figure 7.1

Correlation is significant

(r = .43, N = 53, p < .001)

There is a highly significant relationship between MLU and age for the children when grouped together. However, the relationships between MLU and age were modified when groups were considered individually.

MLU as a function of Age
(All Subjects)

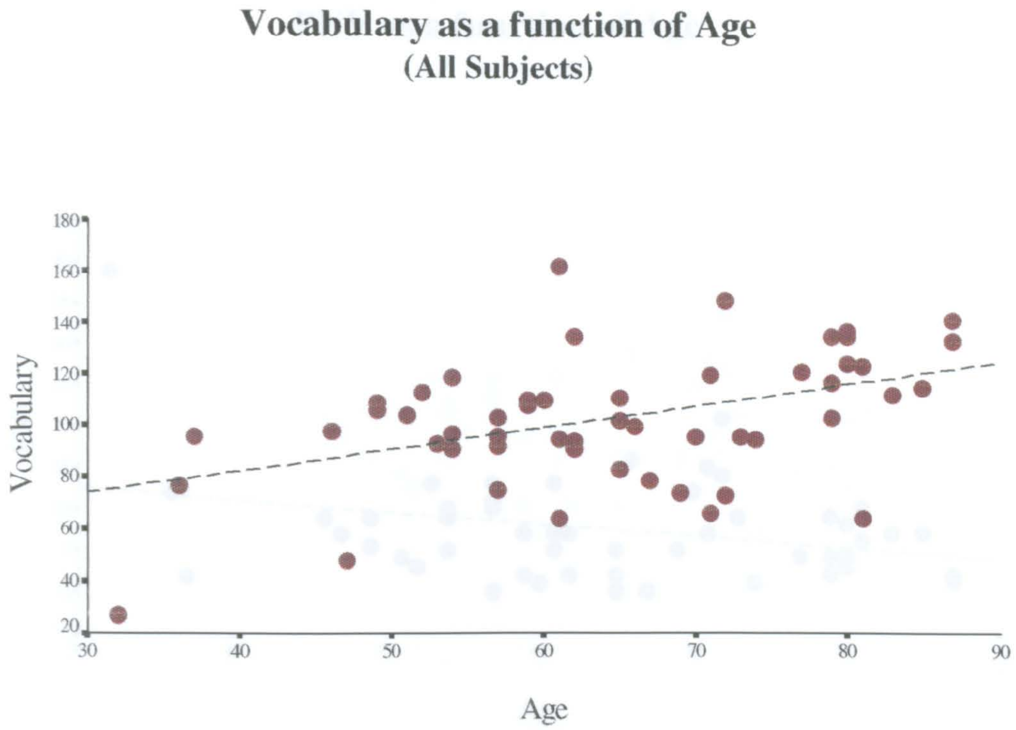


Age

correlation is significant

($r = .43$, $N = 53$, $p < .001$)

Figure 7.2



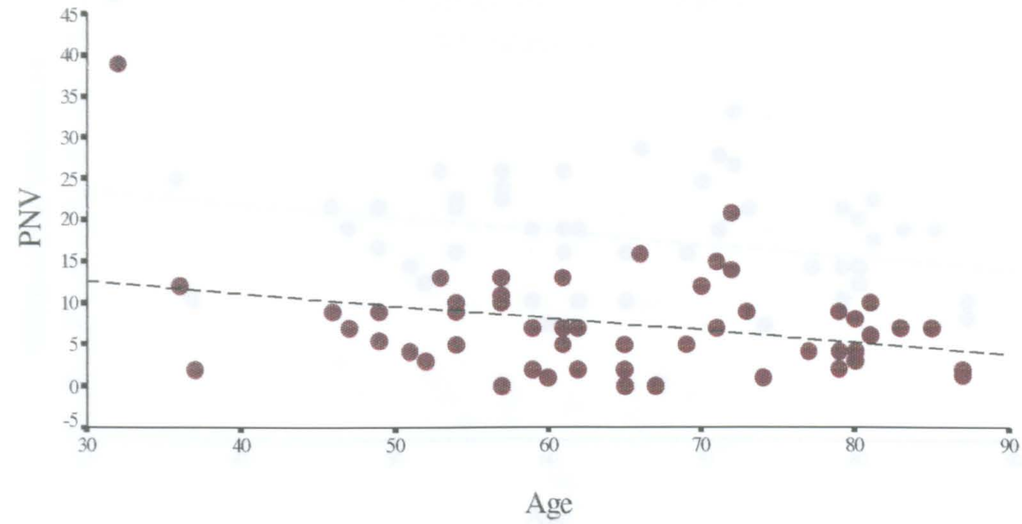
Correlation is significant

(r = .45, N = 53, p < .001)

Figure 7.3

PNV as a function of Age

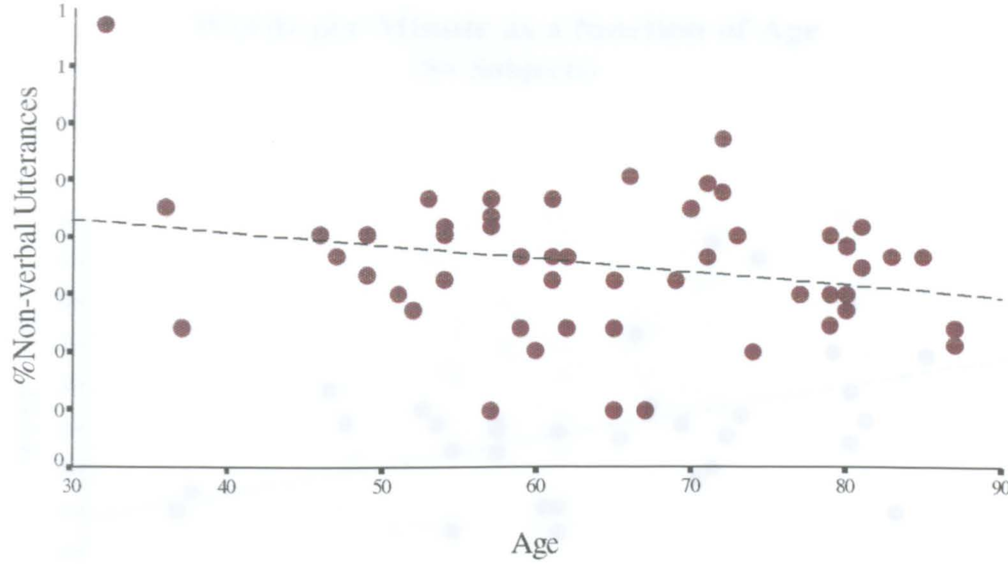
(All Subjects)



Correlation is significant

(r = -.32, N = 53, p < .05)

PNV (arcsin root transformation)
as a function of Age
(All Subjects)



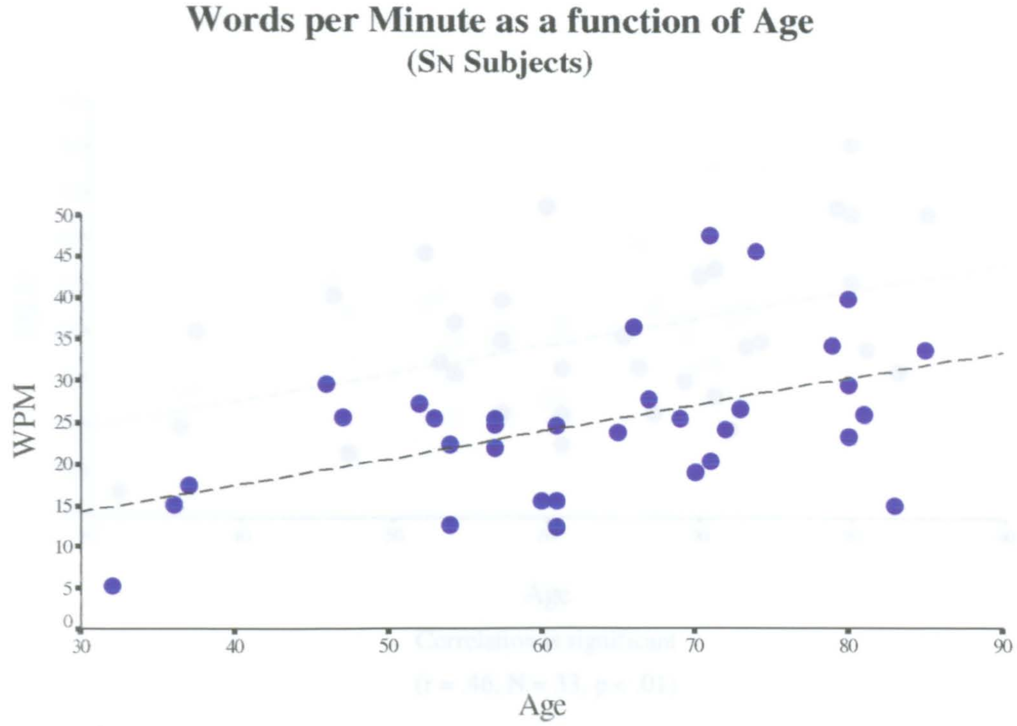
(r = -.25, N = 53, p = .07)

The arcsin root transformation of PNV is presented. The correlation between age and the transformation of PNV did not quite reach significance.

Language Measures by Age for SN1 and SN2 combined – all sensorineural subjects.

RATE MEASURES

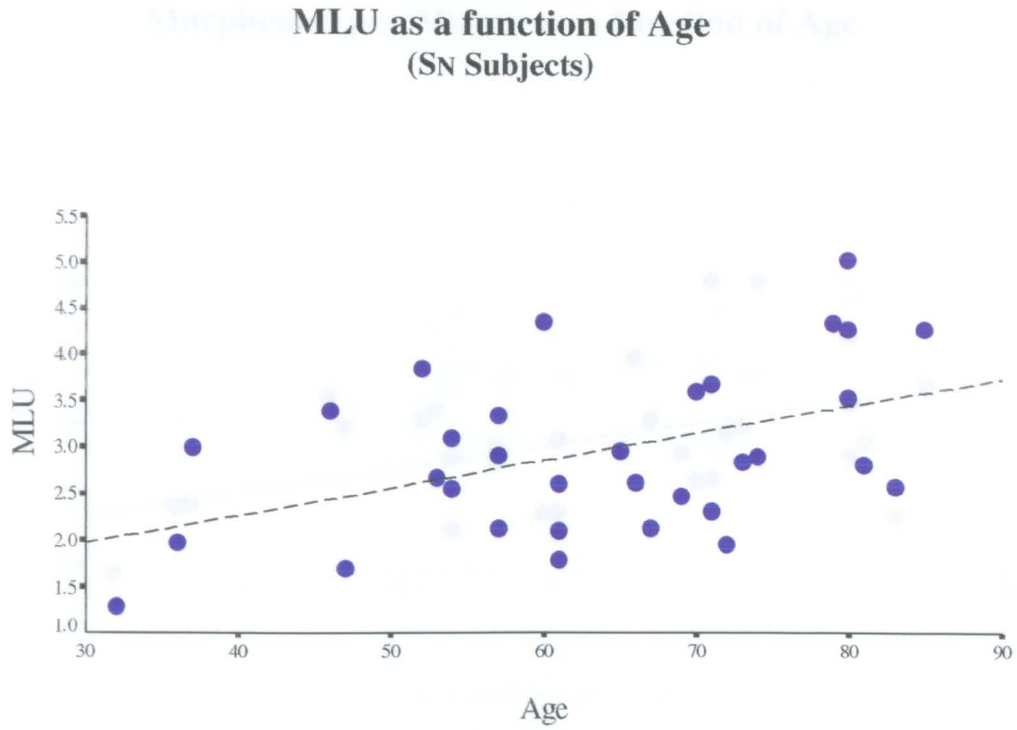
Figure 7.4



Correlation is significant

(r = .49, N = 33, p < .005)

Figure 7.5

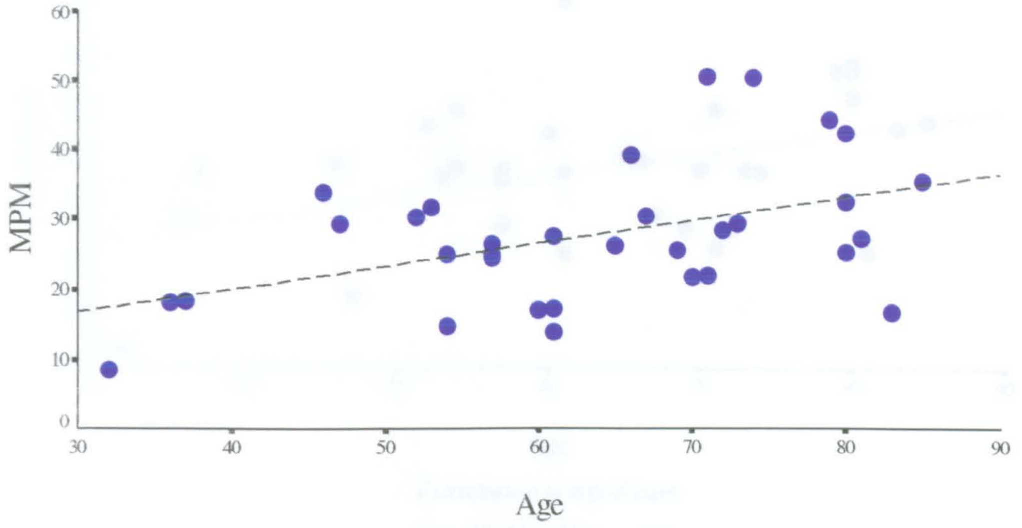


Correlation is significant

(r = .46, N = 33, p < .01)

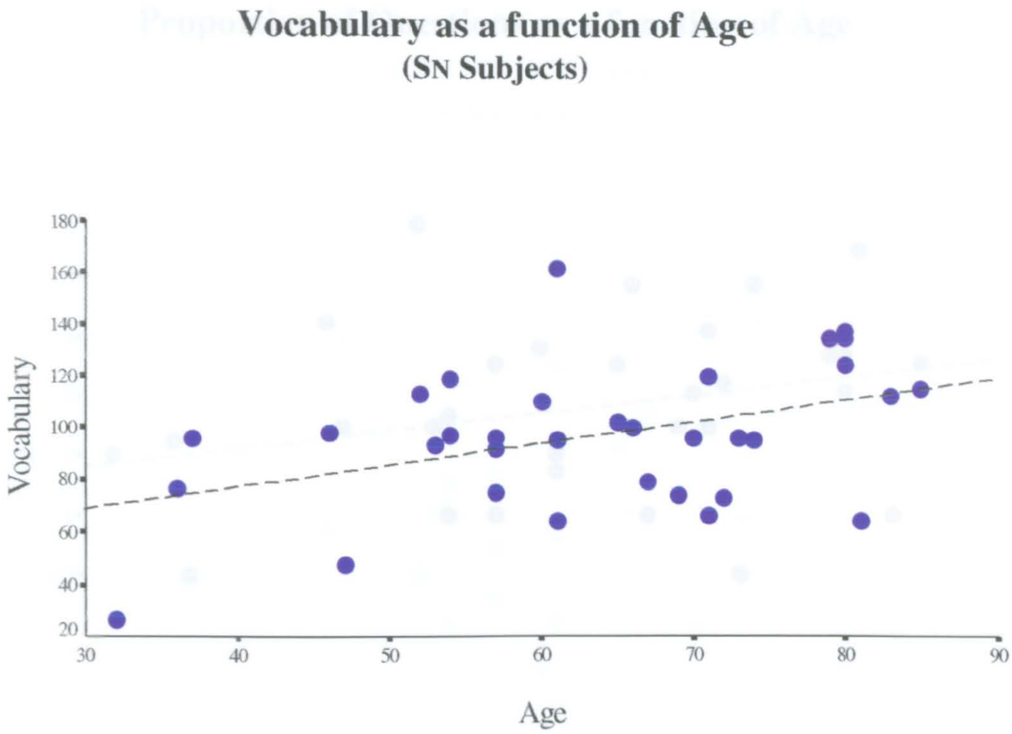
Figure 7.6

Morphemes per Minute as a function of Age
(SN Subjects)



Correlation is significant
(r = .46, N = 33, p < .01)

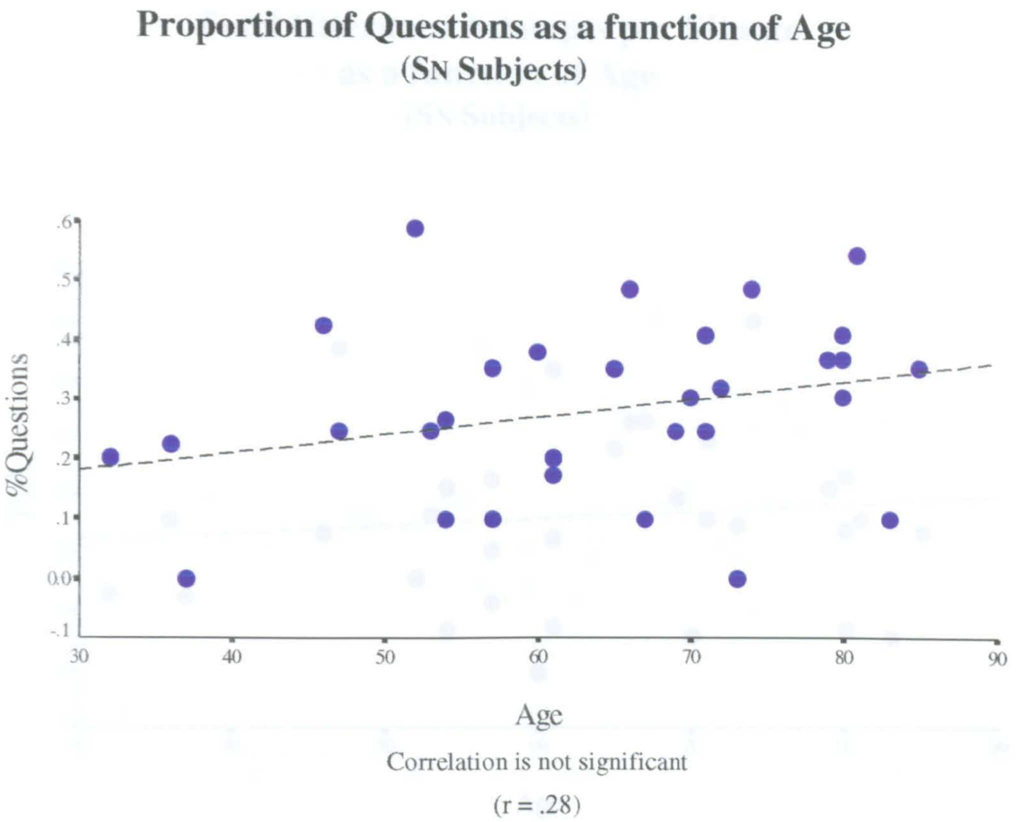
Figure 7.7



Correlation is significant

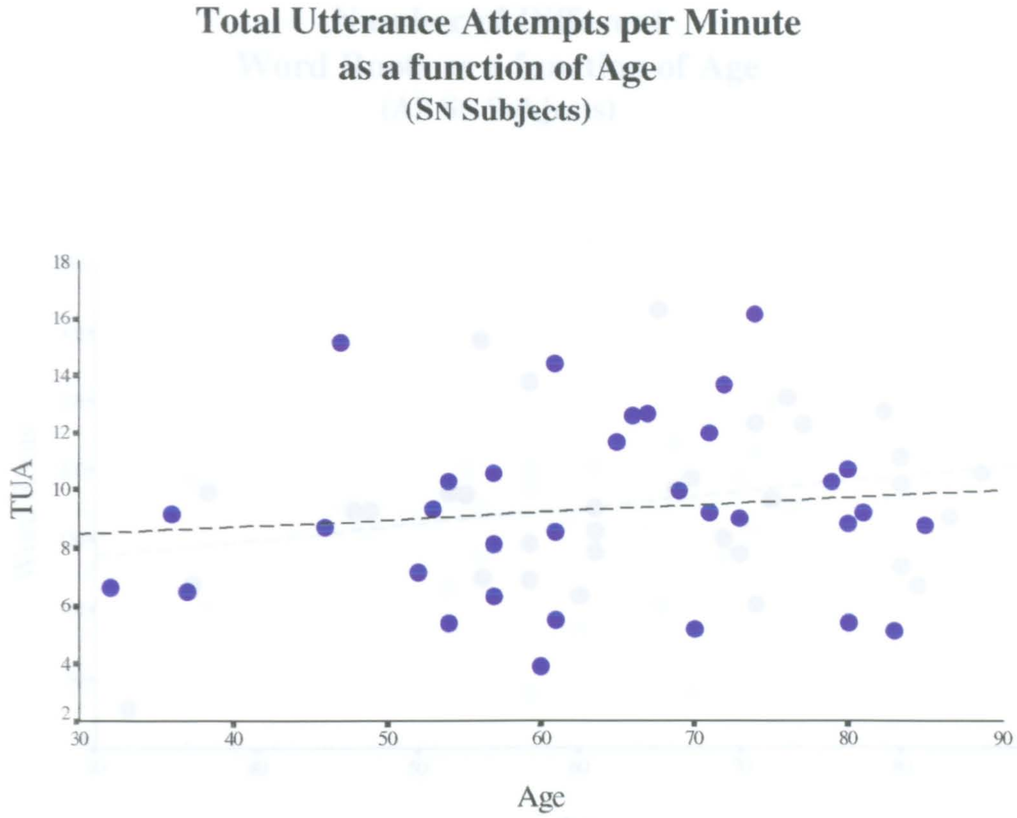
(r = .42, N = 33, p < .01)

Figure 7.8



The arcsin root transformation of PQU is presented. There is a great deal of variability in the performance on this measure by the hearing-impaired children in the study. No relationship emerged from the data between pqu and AGE.

Figure 7.9



partial correlation is not significant

Figure 7.10

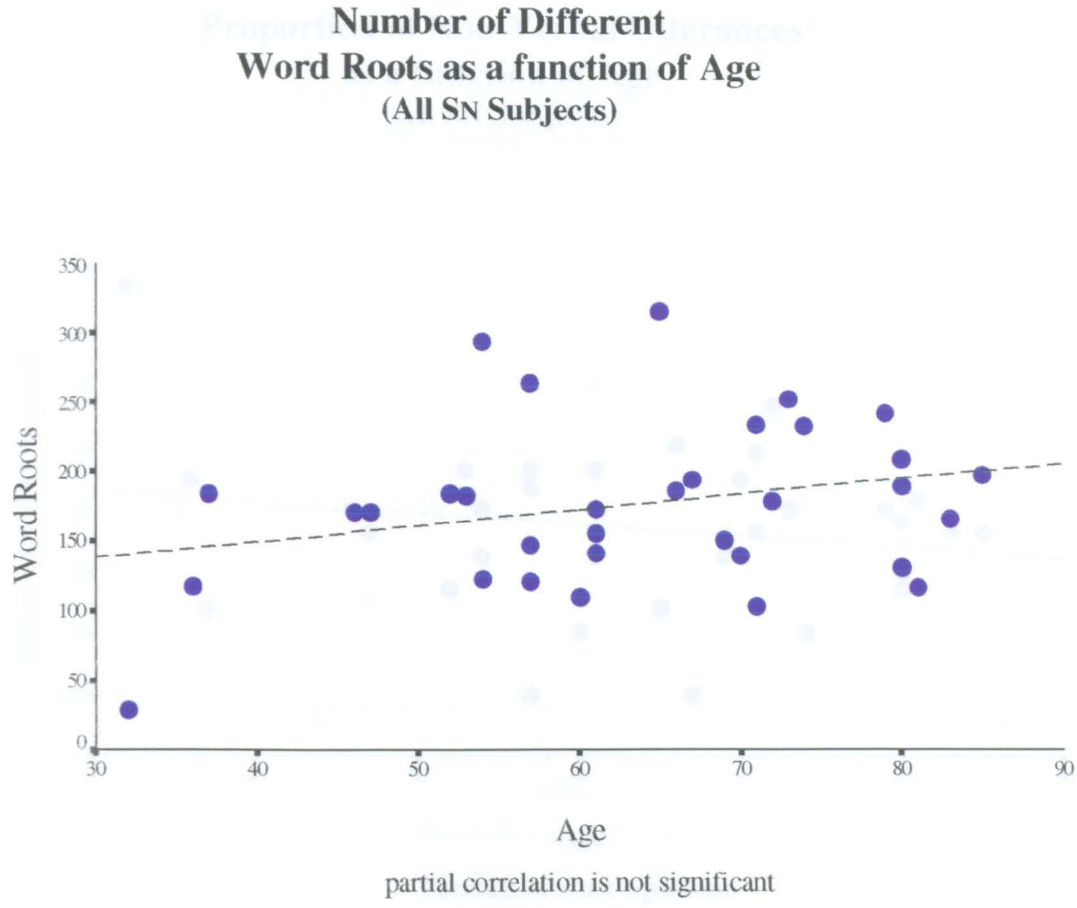
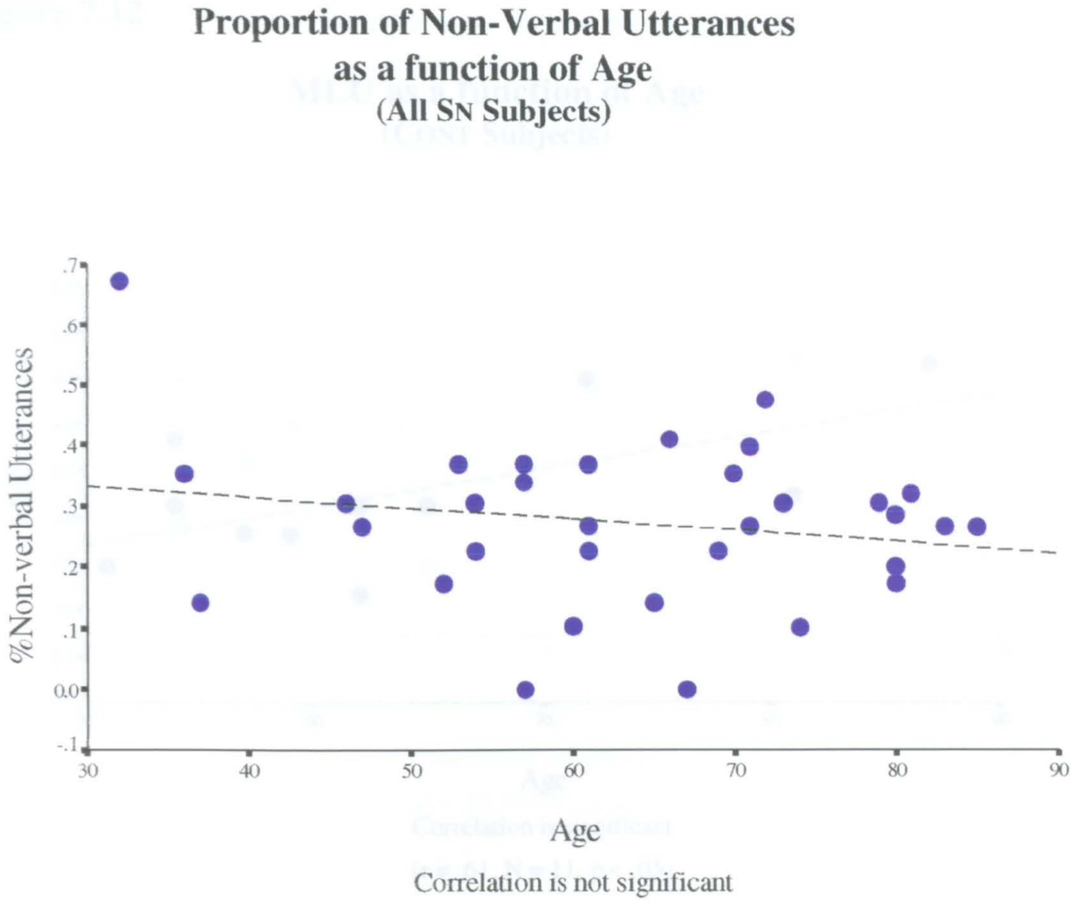

Number of Different
Word Roots as a function of Age
(All SN Subjects)
Word Roots
350
300
250
200
150
100
50
0
30
40
50
60
70
80
90
Age
partial correlation is not significant

Figure 7.11



r = -.28 for pnv.f100 and -.18 (df = 33) for the arcsin root transformation of pnv. The arcsin root transformation is presented. Neither was significantly related to age for the hearing-impaired children in the study.

Figure 7.12

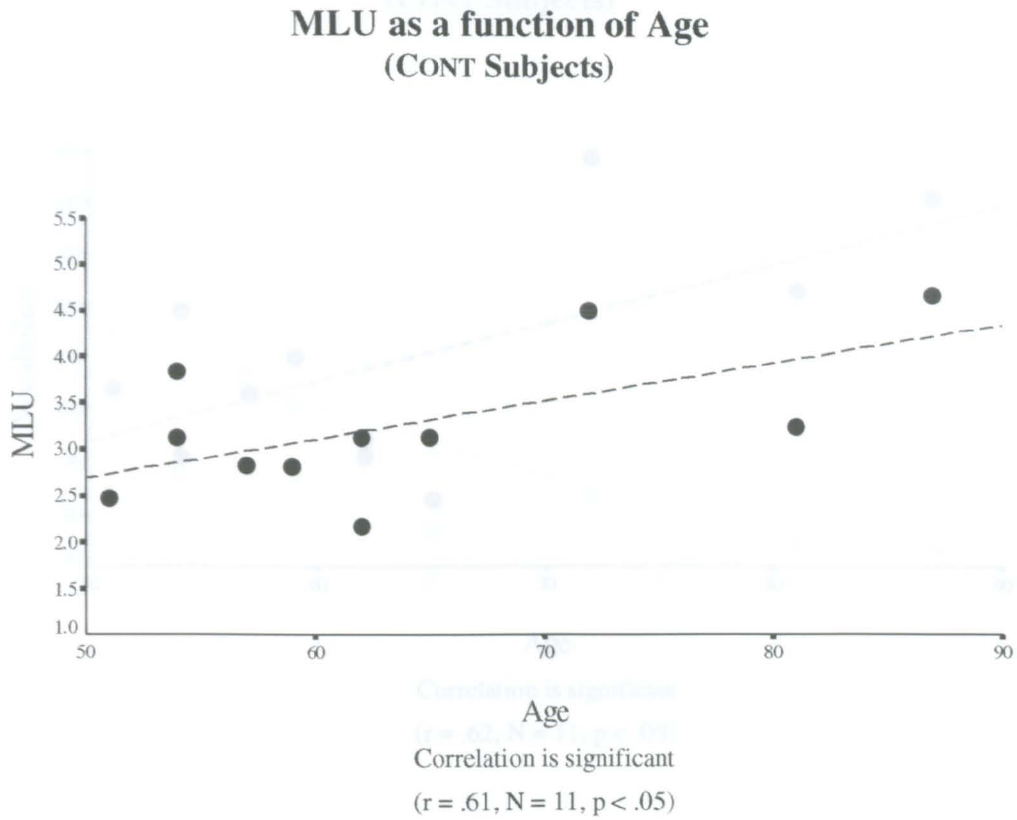
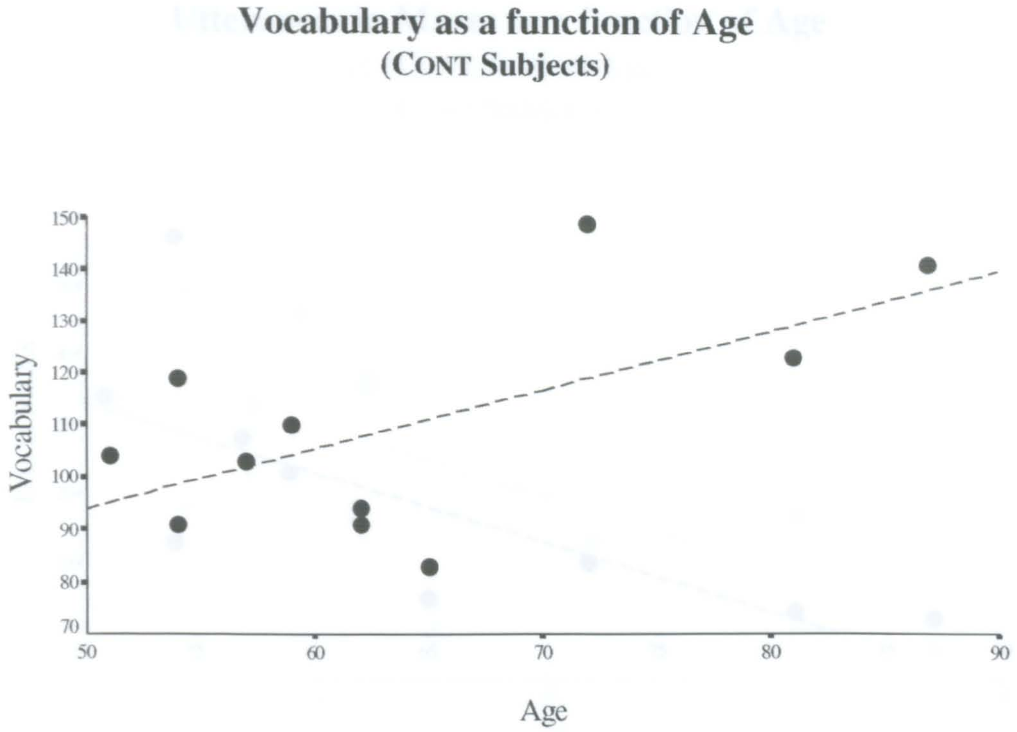

MLU as a function of Age
(CONT Subjects)
MLU
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
50
60
70
80
90
Age
Correlation is significant
(r = .61, N = 11, p < .05)

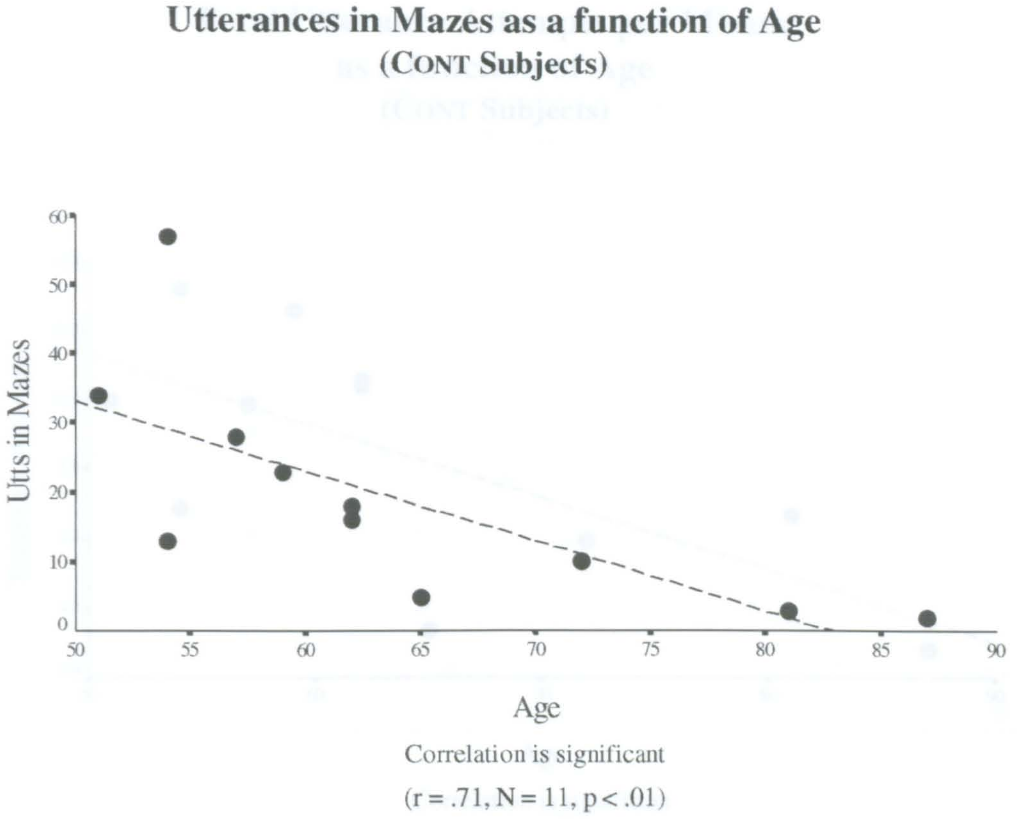
Figure 7.13



Correlation is significant

($r = .62$, $N = 11$, $p < .05$)

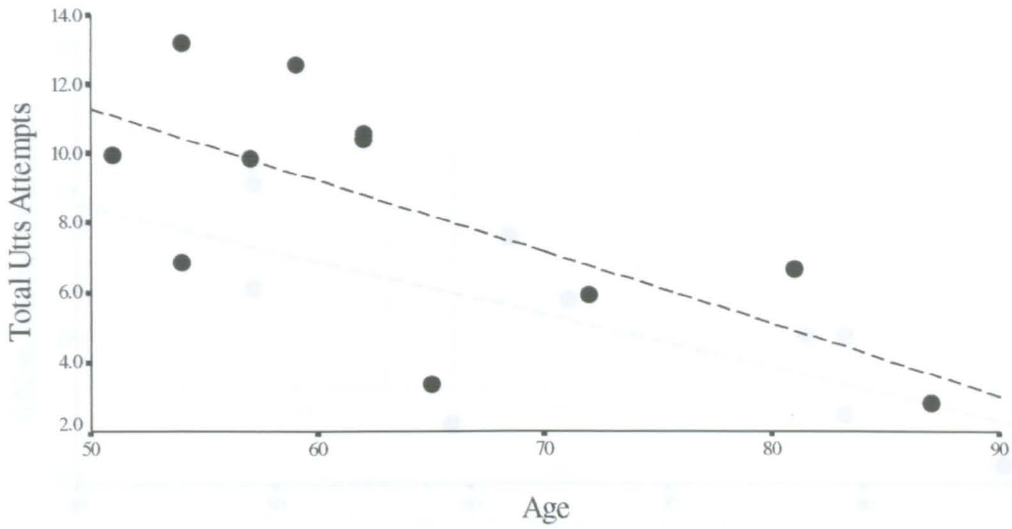
Figure 7.14



Utterances in Mazes as a function of Age
(CONT Subjects)
Utts in Mazes
60
50
40
30
20
10
0
50
55
60
65
70
75
80
85
90
Age
Correlation is significant
(r = .71, N = 11, p < .01)

Figure 7.15

Total Utterance Attempts per Minute as a function of Age (CONT Subjects)



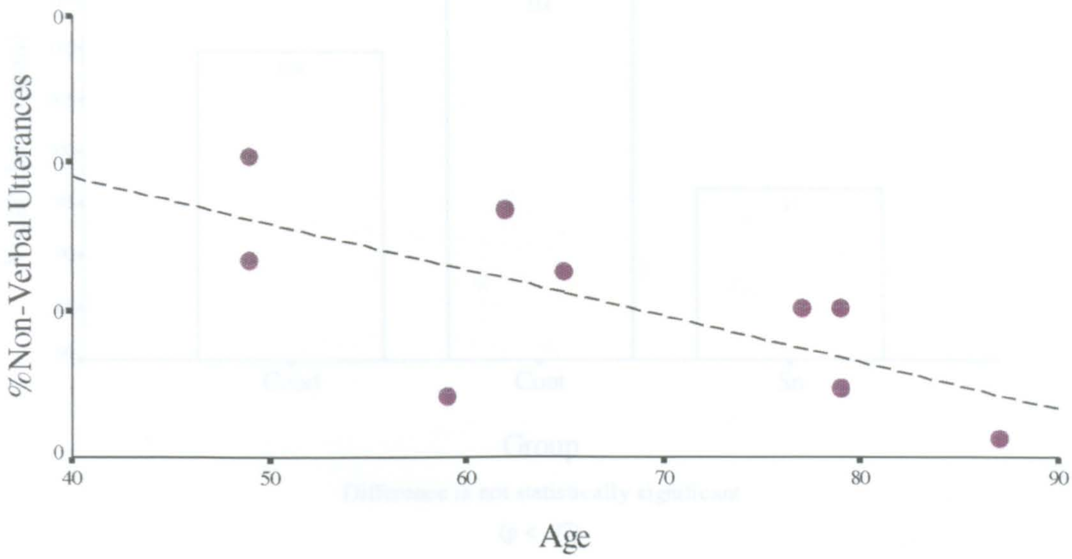
Correlation is significant

(r = -.68, N = 11, p < .05)

Language Measures by Age for Conductive group - COND.

Figure 7.16

PNV as a function of Age
(COND Subjects)



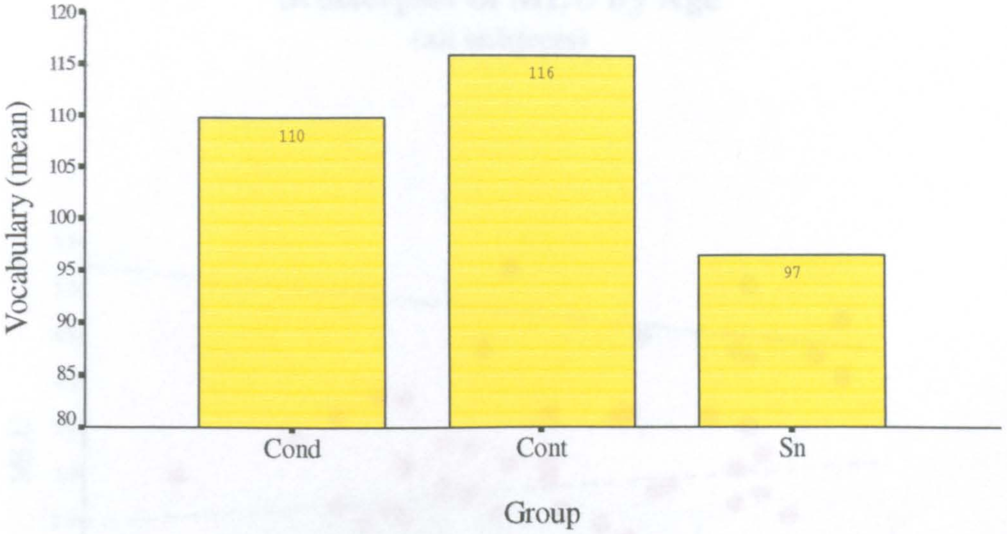
Correlation is significant
(r = .70, N = 9, p < .05)

This was the only measure found to be significantly related to age for this group of children. Both PNV.F100 and the arcsin root transformation of this variable, which is presented above, were found to be significantly related to age.

However, the relationship found between age and PNV for the conductive group has to be interpreted cautiously because of the small number of children in this group.

Figure 7.17

Bar chart of Vocabulary by Subject Group
(SN, CONT and COND)

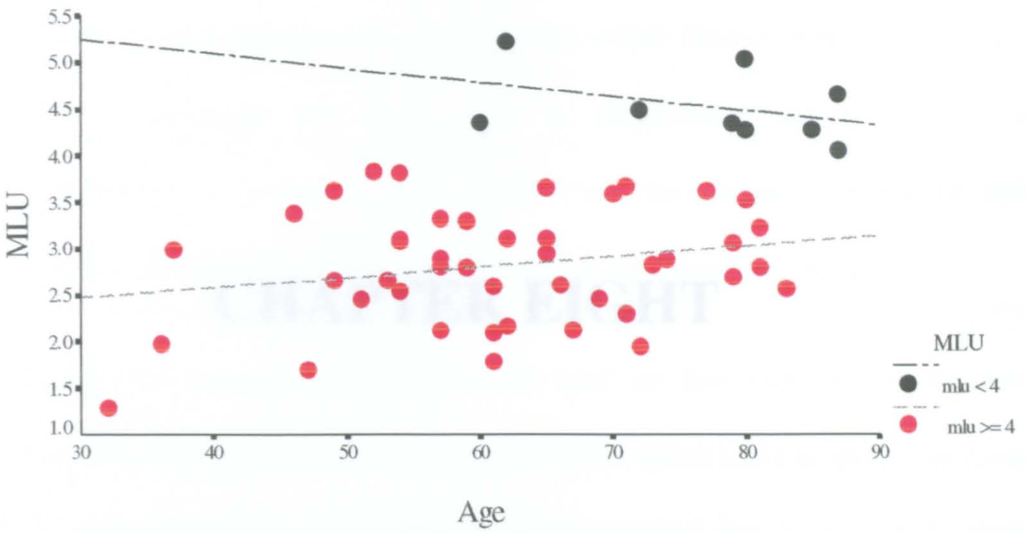


Difference is not statistically significant

(p < .07)

Mean Length of Utterance less than/= 4.0 morphemes and greater than 4.0 morphemes. Several studies stipulate a cut-off point of between 4.0 and 4.5 morphemes, beyond which MLU becomes unreliable as an indicator of language syntax.

Scatterplot of MLU by Age
(all subjects)



correlation is significant

(N=53, p<.001)

CHAPTER EIGHT

CHAPTER EIGHT
SUMMARY AND CONCLUSIONS

8.1 OVERVIEW OF CHAPTERS

Chapter One of this thesis reviewed the epidemiology of permanent childhood hearing-impairment, and issues pertinent to age of detection and intervention for hearing-impaired children were considered. It was established that few studies have evaluated the potential benefits of early detection for children with mild-to-moderate hearing impairments or identified which factors may serve to optimise successful outcomes for them. This is particularly important in light of improvements in detection rates which may see larger numbers of mild-to-moderately hearing-impaired children detected and diagnosed earlier.

Chapter Two reviewed research in the area of first-language acquisition and evaluated some of the studies which have looked specifically at spoken language for deaf and hearing-impaired children. It was concluded that only a small number of studies have focused on language outcomes for hearing-impaired children. Many of these are difficult to compare, differing in the amount of consideration given to variables such as hearing severity and age of intervention. How these are measured and reported may influence results found in observed developmental outcomes for these children.

Chapter Three reviewed the different approaches that have been used to collect and assess children's language for empirical work. The methodology used in this thesis to collect language samples and measure children's language were outlined and some of the potential shortcomings considered. The language transcription conventions used in this research were presented at the end of the chapter.

Chapter Four described the general method and procedure that was employed during the studies described in this thesis. This was followed by the presentation of the first study in Chapter Five. This study incorporated a group of children with mild to profound hearing impairments, aged between 32 and 85 months. Samples of their language produced during an interaction with the major care-giver were recorded and analysed. Language measures derived from these interactions were used to evaluate the influence of hearing severity and age of intervention on the children's spoken language. The results suggested that hearing severity level may not have been an important factor determining outcomes on spoken language measures. However, there was some evidence that early intervention may have corresponded to better performance on certain aspects of spoken language.

Chapter Six presented a range of responses to questions put to the parents of the hearing-impaired children. These questions sought to explore the feelings and attitudes that parents had at the time of the detection and diagnosis of their child's hearing impairment. Responses highlighted that this caused extreme anxiety and stress to parents. The responses suggested that the attitudes and feelings of parents may often be overlooked in service provision focused on the child, and that methods of relaying information about the child's hearing impairment could be improved. Furthermore, family response following the child's detection may play an essential role in ameliorating some of the potentially negative consequences of hearing impairment. It was also clear from parental responses that earlier detection was viewed as important, even when the hearing impairment was mild or moderate.

The second study, presented in Chapter Seven, aimed to replicate findings from the first study. A second group of hearing-impaired children were visited at home using a similar methodology to that employed in the first study. Children's language samples from the first study were re-analysed and included in analyses to enable a range of factors which may affect spoken language to be evaluated with a large sample of hearing-impaired children. Children with conductive hearing-impairments and children with normal-hearing were also looked at for comparison. Group comparisons were difficult to interpret, but there was some indication that in selected aspects of spoken language, hearing-impaired children produced poorer outcomes than normal-hearing children. In contrast to the first study, hearing severity was found to negatively influence one measure of spoken language for the hearing-impaired children. The influence of age of intervention was less clear. The study concluded that a complex range of factors, including the age and hearing level of the child, age of intervention and parental language, may serve to influence the success of outcomes for hearing-impaired children, but that the relationships between factors were confounded by variables difficult to either control for or identify. Parental language, for instance, is treated here as an independent variable, but it may well operate in a self-reinforcing feedback loop along with the child's language.

The heterogeneity of hearing-impaired children make studies of this kind very difficult to conduct and firm conclusions difficult to draw. The hearing-impaired children in the study came from a wide age range and between them represented a wide range of hearing impairments (from 32 to 100 dB HL). It was hoped that by considering outcomes for a number of children, the importance of factors which may ordinarily be obscured by individual differences may be highlighted. The studies produced some evidence that factors related to age of intervention may serve to ameliorate some of the potentially negative consequences of hearing impairment. They also highlight that intervention needs to encompass a range of factors and events which are normally overlooked in studies of this kind. Examples of this may be the role of the family following a child's referral for hearing assessment and their attitude to the child's hearing impairment. As such, the delivery of accessible information and the availability of counselling, or other professional support, may be invaluable elements of any habilitation programme that focuses on the family as well as the child. Child-focused interventions, such as diagnosis and hearing-aid fitting, need to be prompt. However, intervention should not be seen as beginning or ending with either of these stages.

In summary, the studies presented suggest that:

- Excluding profound hearing-impairment, the negative consequences of hearing impairment on spoken language may be ameliorated by other factors, such as the age at referral (Study One).

- The influence of age at referral may include hidden factors that are difficult to measure but may be related to parental attitudes.

- Early intervention for childhood hearing impairment may have benefits for the child's spoken language and communication.

- These benefits may extend to the family, and they may serve to influence the way in which major care-givers respond to and interact with their child.

- Parents view earlier detection as necessary and important, regardless of the level of the child's hearing-impairment.

- Parents undergo a great deal of anxiety and stress at the time of detection and diagnosis. The provision of accessible information and support may be useful at these times.

For the sample of hearing-impaired children that took part in the study, regression analyses suggested that delayed referral for hearing assessment may have negative consequences, particularly in those elements of the child's language that relate to syntax and vocabulary. Prior to this research, few studies had attempted to evaluate the effects of a range of variables on outcomes for hearing-impaired children in Britain and provided evidence that early intervention may correspond to better outcomes in spoken language. A prospective study that monitors language development for these children, as well as broader and longer-term outcomes, such as quality of life, psycho-social adjustment, personal fulfilment and self-esteem would elaborate on this work and enable a more thorough investigation of which factors may serve as important influences and precursors to success in these areas.

8.2 Conclusions

A complex interaction of factors may serve to influence the language and communication of hearing-impaired children. It is suggested that earlier referral, for instance, may have emerged as being important because it enables parents to orientate to the child's hearing-impairment and communication needs *before* the hearing-impairment is diagnosed. Alternatively, it may mark a shift in attitude towards the child, whose behaviour or lack of responsiveness may have been viewed negatively prior to referral. The influence of factors such as this may in turn have important consequences for development in a range of other areas, such as social interaction, self-esteem, educational development and career management.

Parents expressed the desire for earlier and more sensitive assessments for the hearing-impaired children. Targeted neonatal hearing screening is presently most successful at detecting those children with severe-to-profound hearing-impairments, especially those who often have a range of other problems at birth. The potential benefits of early intervention for children with mild-to-moderate hearing impairments remain difficult to evaluate because of the higher mean age of detection for these children. Few children with mild-to-moderate hearing-impairments are identified early enough to enable a thorough evaluation of the potential benefits of very early intervention or comparisons with (i) children detected later, (ii) children with severe-to-profound losses detected early. Universal screening is standard practise in the United States. Thus, studies including populations of mild-to-moderately hearing-impaired children detected very early are feasible and have been conducted (e.g. Levitt et al., 1987; Downs, 1994). However, whilst providing a useful body of research that may inform decisions about screening practise in Britain, these findings are not easily generalised to European (or British) populations in general and do not therefore compensate for the lack of such studies conducted in those contexts.

Cultural factors need to be taken into consideration. Accessible information needs to be made available for parents of potentially hearing-impaired children. The studies in this thesis focused on a sub-group of hearing-impaired children and their families that did not represent the wealth of cultures in this country. Services provided, counselling, and habilitation would need to reflect the multi-cultural composition of the district in which they were to be placed. In these circumstances, a range of additional other factors may warrant serious consideration in any attempt to improve outcomes for the children and families involved. This provides an area of recommended study.

8.3 Limitations of the studies

The cross-sectional design of the studies meant that the success of obtaining a sample of the child's language was dependent on the child's state and willingness to participate on the day of the interview. If the child was tired or unwilling to participate, little could be done to ameliorate the situation, and budgetary and time constraints made it difficult to arrange second visits. Studies that incorporate large numbers of participants are important in that findings may be more reliably generalised. Longitudinal studies are imperative for a determination of what might be happening in the course of development.

By necessity, studies of this type rely on volunteers agreeing to participate in the research. Accompanying these participants may be a range of variables which may bias or skew subject-group composition from the outset of the study. It was suggested that this may have influenced outcomes observed for some of the subjects who took part in the second study and comprised the conductive group of children. These variables need to be investigated in more depth. Few studies have specifically considered the impact of 'volunteer bias' in studies of this kind. With a clearer understanding of what may motivate some families to participate in research and others not to, it may be possible to improve the representativeness of subject samples in studies of this sort. For example, the issue of cultural familiarity was raised in Chapter Four, where it was suggested that some families may find participation in research less unfamiliar and daunting than others. These factors should be explored further.

For both studies, the names of potential subjects were derived from CHAC. This may have led to an inadvertent bias in the way in which subjects were targeted for inclusion in the study. For instance, those children who were performing and managing their hearing impairments well may have been put forward for inclusion before those who were experiencing greater difficulties. The research focused on spoken language outcomes, so families who perceived their child to be poor language users may well have chosen not to take part in the study. This influence may also have operated in the opposite direction, such that parents who felt that their children may have something to gain in having their language and communication "assessed" by a researcher may have more readily volunteered to take part in the study. Factors such as these may have served to confound issues and influences under investigation.

A difficulty that arose during the study was in attaining accurate information from other service bodies which may provide intervention services for hearing-impaired children. For example, it proved difficult to determine what support the children in the study were receiving from Educational Services. Information relating to this was only provided for 37% of participating children. This makes it particularly difficult to gain a clear picture of the various types of intervention that hearing-impaired children may be receiving.

The centralisation of information (via a database) relating to hearing-impaired children and the services provided across districts may be invaluable. Gaining a fuller profile of intervention for each child may then be possible – formal, service provision as well as intervention factors relating to family attitudes and management strategies, may help us to accurately tease out which factors are important for hearing-impaired children. Centralised information can lead to people feeling vulnerable, but if long-term large scale projects are to occur, this may be one of the few ways forward. Thus, such co-ordination of service provision could be accessed for research purposes. It is hoped that this would be to the ultimate benefit of hearing-impaired children and their families.

8.4 RECOMMENDATIONS

Some recommendations can be made on the basis of the findings and these are presented below.

- Support for hearing-impaired children and their families can be improved.

- Family-centred services should be implemented that take into consideration families' needs for information and support before, at, and following the detection and diagnosis of a hearing-impaired child.

- Information delivery and support for parents could be usefully introduced at the point of child referral.

- The feelings and attitudes of the parents at the time of detection and diagnosis need to be evaluated. These may have important implications for intervention programmes provided for the children and their families prior to, during, and following the detection of a hearing impairment.

- Longer-term prospective projects should be started to evaluate the influence of hearing-impairment, service provision, intervention strategies and family variables (e.g. attitudes) on a range of outcomes (short- and long-term) for hearing-impaired individuals and their families.

- Early intervention – referral for hearing assessment followed by prompt hearing-aid provision if necessary – needs to be viewed as important for children with all levels of hearing-impairment.

- The role of the major care-giver(s) in supporting the development of the hearing-impaired child should be explored during and beyond early development.

Broadly, interventions for hearing-impaired children can be categorised as (i) technological or (ii) non-technological. Technological interventions include detecting and diagnosing hearing impairment with sensitivity and specificity, followed by prompt hearing-aid fitting, and hearing-aid monitoring. Non-technological advances include educational support provision for the child, speech/language training, and support aimed at informing parents and reducing their stress and anxiety following the detection of the hearing impairment.

Both elements are undoubtedly important for the effective detection and intervention of permanent childhood hearing-impairment. However, many technological advances have been made in this area. Fewer advances have been made in information provision, support, and family-centred interventions and as the weaker of the two areas they perhaps must be made central to any intervention programme. The child is greatly affected by its primary carer(s), so informing care-givers and providing counselling and support may greatly enhance the effect of other interventions and thus outcomes for hearing-impaired children.

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APPENDIX

APPENDIX

Subject Profiles: Sensorineural Group

All subjects were resident in the East Midlands region at the time of the study.

Hearing thresholds presented are left/right averages. Mid-range averages are calculated across frequencies 1, 2 and 4 kHz where available. Low-range averages are calculated across frequencies 0.5, 1 and 2 kHz where available.

Child: DA	
Date of Birth:	02-07-83
Age at interview:	73
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 58.3 mid freq R/L ave: 58.75
date of referral:	09-04-84
date of first appointment:	11-05-84
date of hearing aid fitting:	---06-85 (---03-86)
Tymp history:	fluctuating conductive loss
Tymp present:	normal
Audiological assessments:	ATT, FFR, PTA[1]
Type of hearing imp:	sensorineural/mixed
Cause: unknown	
Other details: many DNAs postponed confirmation.	

Pure Tone Thresholds

Child: DA

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	-	45	50	50	55	**48.3**	**50.0**
Left	-	65	70	70	65	**68.3**	**67.5**

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[1] ATT is automated toy-test

FFR is free-field response testing

PTA is pure tone audiometry

Child: JA	
Date of Birth:	17-06-86
Age at interview(s):	37/60
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 59 mid freq R/L ave: 61
date of referral:	14-07-87
date of first appointment:	04-08-87
date of hearing aid fitting:	---03-89
Tymp history:	abnormalities/grommets
Tymp present:	normal
Audiological assessments used:	distraction/performance testing, ATT, FFR, PTA
Type of hearing imp:	high tone sensorineural
Cause: genetic	
Other details: problem confounded by conductive loss at first making diagnosis difficult.	

Pure tone thresholds

Child: JA(I)

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	30	60	–	60	**50.0**	**50.0**
Left	–	60	60	–	70	**63.3**	**63.3**

JA(II)

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	40	70	75	70	**61.67**	**63.75**
Left	–	45	60	65	65	**56.67**	**58.75**

Child: AA	
Date of Birth:	01-10-84
Age at interview(s):	57/80
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 81.7 mid freq R/L ave: 82.5
date of referral:	14-07-87
date of first appointment:	04-08-87
date of hearing aid fitting:	08-10-87
Tymp history:	middle ear problems
Tymp present:	normal
Audiological assessments used:	Toytest; FFR;PTA
Type of hearing imp:	bilateral sn (progressive)
Cause: genetic, deafness in immediate family.	
Other details:	

Pure tone thresholds

Child: AA(I)

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	35	80	80	65	**65**	**65.00**
Left	–	35	85	85	70	**68**	**68.75**

AA(II)

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	65	95	85	80	**81.67**	**81.25**
Left	–	60	95	90	90	**81.67**	**83.75**

AA (original)

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	65	70	100	90	85	**81.25**	**86.25**
Left	50	75	105	115	80	**86.25**	**93.75**

Child: SB	
Date of Birth:	14-06-84
Age at interview(s):	61/83
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 78.3 mid freq R/L ave: 78.1
date of referral:	10-07-87
date of first appointment:	19-08-87
date of hearing aid fitting:	16-09-87
Tymp history:	some problems
Tymp present:	normal
Audiological assessments used:	Toytest; FFR; PTA
Type of hearing imp:	bilateral sensorineural
Cause: dominant hereditary	
Other details: adenoidectomy conducted	

Pure tone thresholds

Child: SB(I)

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	65	70	75	65	**70.00**	**68.75**
Left	–	65	80	85	80	**76.67**	**77.50**

SB(II)

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	70	80	80	70	**75.00**	**75.00**
Left	–	65	90	90	80	**81.67**	**81.25**

SB (original)

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	80	75	85	75	**80.00**	**78.75**
Left	–	60	90	90	85	**80.00**	**81.25**

Child: JCa	
Date of Birth:	19-02-84
Age at interview:	65
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 74 mid freq R/L ave: 75.75
date of referral:	10-06-85 (ENT)
date of first appointment:	11-10-85 (CHAC)
date of hearing aid fitting:	---08-85 (Queens)
Tymp history:	some abnormality
Tymp present:	normal
Audiological assessments used:	FFR, PTA
Type of hearing imp:	sensorineural
Cause: Pierre-Robin syndrome	
Other details: CLP insertion	

Pure tone thresholds

Child: JCa

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	60	75	75	85	**70**	**77.5**
Left	–	75	85	75	75	**78**	**74.0**

Child: JCl	
Date of Birth:	27-01-83
Age at interview:	79
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 95 mid freq R/L ave: 96.25
date of referral:	24-01-84
date of first appointment:	15-02-84
date of hearing aid fitting:	22-08-84
Tymp history:	normal
Tymp present:	normal
Audiological assessments:	FFR, PTA
Type of hearing imp:	sensorineural
Cause: -	
Other details: other disorders–hypopituitarism, CLP	

Pure tone thresholds

Child: JCl

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	80	95	95	95	**90**	**91.25**
Left	–	105	100	95	105	**100**	**101.25**

Child: TH	
Date of Birth:	03-12-83
Age at interview:	67
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 58.3 mid freq R/L ave: 66.9
date of referral:	-
date of first appointment:	20-07-87
date of hearing aid fitting:	11-08-87
Tymp history:	normal
Tymp present:	normal
Audiological assessments:	FFR, PTA
Type of hearing imp:	sensorineural
Cause: congenital rubella	
Other details: family DNAs cause of diagnosis delay	

Pure tone thresholds

Child: TH

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	low ave	mid ave
Right	–	15	20	45	65	70	**26.67**	**36.25**
Left	–	70	90	110	120	100+	**90.00**	**97.50**

Child: JH	
Date of Birth:	03-11-84
Age at interview:	57
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 99.2 mid freq R/L ave: 100
date of referral:	08-08-85
date of first appointment:	21-08-85
date of hearing aid fitting:	---10-85
Tymp history:	normal
Tymp present:	normal
Audiological assessments used:	Automated toytest, FFR, PTA
Type of hearing imp:	sensorineural
Cause: unknown/genetic	
Other details:	

Pure tone thresholds

Child: JH

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	100	105	100	110	**101.67**	**104.00**
Left	–	100	90	100	95	**96.67**	**96.25**

Child: KH	
Date of Birth:	16-05-83
Age at interview:	74
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 76.7 mid freq R/L ave: 75.6
date of referral:	02-02-84
date of first appointment:	-
date of hearing aid fitting:	-
Tymp history:	-
Tymp present:	-
Audiological assessments used:	FFR, PTA
Type of hearing imp:	sensorineural
Cause:	
Other details:	

Pure tone thresholds

Child: KH

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	75	80	70	75	**75.0**	**75.00**
Left	–	85	80	70	70	**78.3**	**76.25**

Child: CN	
Date of Birth:	17-01-85
Age at interview:	54
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 55.8 mid freq R/L ave: 55
date of referral:	22-04-88
date of first appointment:	28-06-88
date of hearing aid fitting:	13-07-88
Tymp history:	normal
Tymp present:	normal
Audiological assessments used:	ATT, FFR (Warble tones), PTA
Type of hearing imp:	moderate bilateral sensorineural
Cause: suspected genetic	
Other details: freq ear infections as child, visual problems present	

Pure tone thresholds

Child: CN

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	50	55	60	50	**55.00**	**53.75**
Left	–	50	55	65	55	**56.67**	**56.25**

Child: VR	
Date of Birth:	28-01-85
Age at interview:	53
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 35.8 mid freq R/L ave: 40.6
date of referral:	08-11-85
date of first appointment:	02-12-85
date of hearing aid fitting:	---05-85
Tymp history:	abnormality/ear effusions
Tymp present:	normal
Audiological assessments used:	Automated toytest, aided FFR, PTA
Type of hearing imp:	sensorineural/mixed
Cause: unknown, suspected genetic.	
Other details: mild articulation delay for certain speech sounds.	

Pure tone thresholds

Child: VR

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	20	50	50	55	**40.00**	**43.75**
Left	–	20	25	50	55	**31.60**	**37.50**

Child: TW	
Date of Birth:	31-12-86
Age at interview:	32
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 77.5 mid freq R/L ave: 78
date of referral:	-
date of first appointment:	-
date of hearing aid fitting:	-
Tymp history:	-
Tymp present:	-
Audiological assessments used:	distraction test, PTA
Type of hearing imp:	
Cause:	
Other details:	

Pure tone thresholds

Child: TW

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	45	90	95	80+	**76.67**	**77.50**
Left	–	50	90+	95	80+	**78.33**	**78.75**

Child: KWi	
Date of Birth:	18-06-84
Age at interview:	61
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 43.3 mid freq R/L ave: 43.75
date of referral:	23-02-88
date of first appointment:	23-02-88
date of hearing aid fitting:	---04-88
Tymp history:	normal
Tymp present:	normal
Audiological assessments:	FFR, PTA
Type of hearing imp:	mild sensorineural
Cause: unknown	
Other details: passed H/V screen, parental concern.	

Pure tone thresholds

Child: KWi

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	40	40	50	45	**43.30**	**43.75**
Left	–	40	40	50	45	**43.30**	**43.75**

Child: KWo	
Date of Birth:	08-08-85
Age at interview:	47
Subject category:	SN1 (SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 85.8 mid freq R/L ave: 86.9
date of referral:	23-10-85
date of first appointment:	18-11-85
date of hearing aid fitting:	04-03-87
Tymp history:	abnormal
Tymp present:	normal
Audiological assessments:	FFR, PTA
Type of hearing imp:	sensorineural/mixed
Cause: unconfirmed, perinatal risk factors	
Other details: grommets and tympanometry received	

Pure tone thresholds

Child: KWo

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	80	95	90	90	**88.30**	**88.75**
Left	–	80	85	85	90	**83.30**	**85.00**

Child: WW	
Date of Birth:	26-10-83
Age at interview:	66
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 80 mid freq R/L ave: 84.4
date of referral:	12-10-87
date of first appointment:	---02-88
date of hearing aid fitting:	---03-88
Tymp history:	normal
Tymp present:	normal
Audiological assessments:	FFR, PTA
Type of hearing imp:	progressive sensorineural
Cause: hereditary cochlear degenerative disorder, autosomal recessive	
Other details:	

Pure tone thresholds

Child: WW

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	55	70	75	105	100	**76.25**	**87.50**
Left	85	80	90	80	75	**83.75**	**81.25**

Subject Profiles (Study 2)

All subjects, at the time of participation in the study, were resident in the East Midlands region.

Child: AB	
Date of Birth	28-11-85
Age at interview:	80
Subject category:	SN1 (SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 43 mid freq R/L ave: 62.5
date of referral:	19-09-86
date of first appointment:	13-11-86
date of hearing aid fitting:	03-12-86
Tymp history:	normal
Tymp present:	normal
Audiological assessments used:	warble tones/FFR, PTA
Type of hearing imp:	high freq sensorineural
Cause: unknown	
Other details:	

Pure tone thresholds

Child: AB

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	15	5	65	85	95	**42.50**	**62.50**
Left	10	10	65	90	85	**43.75**	**62.50**

Child: AC	
Date of Birth	02-08-88
Age at interview:	46
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment:	mid freq R/L ave: 48.75
date of referral:	19-06-89
date of first appointment:	16-11-89
date of hearing aid fitting:	09-01-92
Tymp history:	abnormal
Tymp present:	normal
Audiological assessments used:	toytest (voice), PTA
Type of hearing imp:	mixed/sensorineural
Cause: unknown	
Other details: bilateral grommets fitted ("89), verification of sn loss delayed by presence conductive loss & OME	

Pure tone thresholds

Child: AC

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	40	55	60	50	–	**51.25**
Left	–	35	60	50	40	–	**46.25**

Child: CC	
Date of Birth:	21-08-85
Age at interview:	70
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 102.5 mid freq R/L ave: 101.5
date of referral:	03-06-86
date of first appointment:	05-06-86
date of hearing aid fitting:	25-10-88
Tymp history:	normal
Tymp present:	normal
Audiological assessments used:	Toytest; aided FFR; PTA
Type of hearing imp:	bilateral sn (stable)
Cause: genetic	
Other details: child missed by H/V screen	

Pure tone thresholds

Child: CC

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	90	100	110	100	**100**	**100**
Left	–	95	110	110	95	**105**	**103**

Child: NC	
Date of Birth	17-08-85
Age at interview:	81
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment:	low freq R/L ave: 94.4 mid freq R/L ave: 102.5
date of referral:	18-05-88
date of first appointment:	22-06-88
date of hearing aid fitting:	23-06-88
Tymp history:	normal
Tymp present:	normal
Audiological assessments used:	Aided warble tone (FFR), PTA
Type of hearing imp:	sensorineural
Cause: suspected Pendred's Syndrome	
Other details: delayed detection, age 2;9 before diagnosed properly.	

Pure tone thresholds

Child: NC

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	80	80	90	105	110	**88.75**	**96.25**
Left	85	95	105	115	120+	**100.00**	**108.75**

Child: JCr	
Date of Birth:	19-04-86
Age at interview:	61
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 103.75 mid freq R/L ave: 103.75
date of referral:	22-12-86
date of first appointment:	10-02-87
date of hearing aid fitting:	26-03-87
Tymp history:	normal
Tymp present:	normal
Audiological assessments used:	PTA
Type of hearing imp:	bilateral sn (stable)
Cause: non-syndromic autosomal recessive	
Other details:	

Pure tone thresholds

Child: JCr

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	90	105	105	90	**97.5**	**97.5**
Left	–	105	110	110	115	**110.0**	**110.0**

Child: AFI	
Date of Birth	26-08-89
Age at interview:	36
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment:	mid freq R/L ave: 95
date of referral:	10-10-89
date of first appointment:	06-11-89
date of hearing aid fitting:	13-12-89
Tymp history:	abnormal
Tymp present:	some abnormality
Audiological assessments used:	warble tone (aided), PTA
Type of hearing imp:	mixed/sensorineural
Cause: unknown	
Other details: bilateral grommets inserted twice ('91/'92) & myringotomy.	

Pure tone thresholds

Child: AFI

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	100	105	–	85	–	97
Left	–	95	105	–	80	–	93

Child: AFo	
Date of Birth	30-03-87
Age at interview:	66
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 98 mid freq R/L ave: 102
date of referral:	22-03-89
date of first appointment:	20-06-89
date of hearing aid fitting:	21-07-89
Tymp history:	abnormal
Tymp present:	abnormal
Audiological assessments used:	automated toytest, FFR (aided), PTA
Type of hearing imp:	mixed/sensorineural
Cause: genetic/ family history	
Other details: awaiting grommets at time of interview.	

Pure tone thresholds

Child: AFo

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	3000Hz	4000 Hz	low ave	mid ave
Right	–	65	105	95	90	120	**88.75**	**96.25**
Left	–	85	110	115	120	120	**107.50**	**107.50**

Child: MHa	
Date of Birth	03-07-86
Age at interview:	71
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment:	low freq R/L ave: 35 mid freq R/L ave: 40.6
date of referral:	27-06-91
date of first appointment:	03-07-91
date of hearing aid fitting:	25-07-91
Tymp history:	normal
Tymp present:	normal
Audiological assessments used:	Automated toytest, warble tone (aided), PTA
Type of hearing imp:	mild sensorineural
Cause: genetic/unconfirmed	
Other details: -	

Pure tone thresholds

Child: MHa

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	30	35	50	60	**38**	**43.75**
Left	–	25	20	50	55	**32**	**37.50**

Child: MHo	
Date of Birth	02-10-87
Age at interview:	57
Subject category:	SN1 (SCBU)
Degree of hearing impairment:	low freq R/L ave: 66.25 mid freq R/L ave: 86.25
date of referral:	11-02-88
date of first appointment:	27-04-88
date of hearing aid fitting:	06-04-89
Tymp history:	some abnormality
Tymp present:	some abnormality
Audiological assessments used:	Automated toytest, FFR, PTA.
Type of hearing imp:	h.f. mixed/sensorineural
Cause: unconfirmed	
Other details:	

Pure tone thresholds

Child: MHo

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	35	50	85	85	110	**63.75**	**82.50**
Left	35	60	85	95	120+	**68.75**	**90.00**

Child: AL	
Date of Birth	22-12-87
Age at interview:	54
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	mid freq R/L ave: 52.5
date of referral:	12-08-88
date of first appointment:	23-09-88 (?)
date of hearing aid fitting:	---02-89
Tymp history:	normal
Tymp present:	normal
Audiological assessments used:	Automated toytest, FFR (aided), PTA
Type of hearing imp:	mild sensorineural
Cause: unknown/genetic	
Other details: difficult to test leading to delay in HA fitting.	

Pure tone thresholds

Child: AL

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	60	60	–	35	–	52
Left	–	70	60	–	30	–	53

Child: CJ	
Date of Birth	12-06-85
Age at interview:	85
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 38.5 mid freq R/L ave: 41.25
date of referral:	11-03-86
date of first appointment:	07-04-86
date of hearing aid fitting:	19-01-89
Tymp history:	abnormality (right)
Tymp present:	"
Audiological assessments used:	Automated toytest, FFR (aided), PTA
Type of hearing imp:	sensorineural
Cause: unknown	
Other details: family extremely reluctant to accept existence of hearing loss or to allow aiding, thus delay.	

Pure tone thresholds

Child: CJ

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	30	40	40	50	**37.0**	**40.0**
Left	–	35	40	45	50	**40.0**	**42.5**

Child: DM	
Date of Birth	31-10-85
Age at interview:	80
Subject category:	SN1 (SCBU)
Degree of hearing impairment (dB HL):	low freq R/L ave: 45.6 mid freq R/L ave: 55.6
date of referral:	11-02-86
date of first appointment:	23-05-86
date of hearing aid fitting:	15-12-89
Tymp history:	abnormal
Tymp present:	normal (spontaneous resolution)
Audiological assessments used:	Automated toytest, FFR (aided), PTA (air cond)
Type of hearing imp:	mod h.f. sensorineural
Cause: unknown	
Other details: loss not confirmed until later visit, no concerns after first appointment, thus delay in HA fitting	

Pure tone thresholds

Child: DM

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	30	35	60	60	60	**46.25**	**53.75**
Left	20	40	55	65	70	**45.00**	**57.50**

Child: JM	
Date of Birth	29-09-86
Age at interview:	71
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment (dB HL):	mid freq R/L ave: 95
date of referral:	05-12-88 (to CHAC)
date of first appointment:	02-02-89 (at CHAC)
date of hearing aid fitting:	---09-87
Tymp history:	normal
Tymp present:	normal
Audiological assessments used:	FFR (aided), PTA
Type of hearing imp:	sensorineural
Cause: unknown	
Other details: child already diagnosed and fitted with hearing aids when first seen at CHAC	

Pure tone thresholds

Child: JM

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	–	90	100	105	85	–	**95**
Left	–	90	100	95	95	–	**95**

Child: SN	
Date of Birth	10-08-86
Age at interview:	72
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment:	low freq L/R ave: 98.75 mid freq L/R ave: 102.5
date of referral:	31-03-88
date of first appointment:	09-05-88
date of hearing aid fitting:	06-07-88
Tymp history:	some abnormality
Tymp present:	normal
Audiological assessments used:	FFR (aided), PTA
Type of hearing imp:	sensorineural
Cause: unknown	
Other details: grommets fitted ('91), normal middle ear function since	

Pure tone thresholds

Child: SN

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	80	110	110	115	120	103.75	113.75
Left	90	95	95	95	80	93.75	91.25

Child: RW	
Date of Birth	21-02-88
Age at interview:	52
Subject category:	SN1 (NON-SCBU)
Degree of hearing impairment:	mid freq L/R ave: 102.5
date of referral:	24-11-88
date of first appointment:	22-12-88
date of hearing aid fitting:	23-03-89
Tymp history:	some abnormality (right)
Tymp present:	normal
Audiological assessments used:	toytest, FFR (aided), PTA
Type of hearing imp:	sensorineural
Cause: suspected autosomal recessive inheritence	
Other details: failed H/V screen x2 leading to referral	

Pure tone thresholds

Child: RW

Ear	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	low ave	mid ave
Right	95	95	110	110	105	**102.5**	**105**
Left	85	90	110	105	95	**97.5**	**100**

Subject Profiles: Conductive Group

Child: BA	
Date of Birth	23-09-86
Age at interview:	65 months
Subject category:	COND (SCBU)
Tymp history:	yes
Tymp present:	no
Age seen at ENT clinic:	14 months
Status at time of interview	discharged
Hearing level recorded:	60 dB HL
Intervention received for middle ear problems:	i. surgery (17) ii. iii.
Other problems: none	
Additional details: has twin sister with no middle ear problems	

Child: DH	
Date of Birth	02--03-87
Age at interview:	87 months
Subject category:	COND (SCBU)
Tymp history:	yes
Tymp present:	no
Age seen at ENT clinic:	11 months
Status at time of interview:	discharged
Intervention received for middle ear problems:	i. surgery (11) ii. iii.
Other problems: visual problems	
Additional details: AOM recurrent	

Child: JK	
Date of Birth	16-11-84
Age at interview:	87
Subject category:	COND (SCBU)
Tymp history:	yes
Tymp present:	no
Age seen at ENT clinic:	
Status at time of interview	discharged
Intervention received for middle ear problems:	i. ii. iii.
Other problems:	
Additional details: twin of MK	

Child: LL	
Date of Birth	04-09-85
Age at interview:	77 months
Subject category:	COND (SCBU)
Tymp history:	yes
Tymp present:	no
Age seen at ENT clinic:	9 months
Status at time of interview	
Intervention received for middle ear problems:	i. surgery (21) ii. iii.
Other problems:	
slow motor development	
Additional details:	

Child: RM	
Date of Birth	31-01-88
Age at interview:	49 months
Subject category:	COND (SCBU)
Tymp history:	yes
Tymp present:	no
Age seen at ENT clinic:	16 months
Status at time of interview	discharged
Intervention received for middle ear problems:	i. surgery (20) ii. iii.
Other problems:	
Additional details: twin	

Child: MM	
Date of Birth	16-11-84
Age at interview:	87
Subject category:	COND (SCBU)
Tymp history:	yes
Tymp present:	no
Age seen at ENT clinic:	–
Status at time of interview	unspecified
Intervention received for middle ear problems:	i. none ii. none iii. none
Other problems: none	
Additional details: twin	

Child: AM	
Date of Birth	28-07-85
Age at interview:	79 months
Subject category:	COND (SCBU)
Tymp history:	yes
Tymp present:	no
Age seen at ENT clinic:	15 months
Status at time of interview	discharged
Intervention received for middle ear problems (age):	i. surgery (22) ii. iii.
Other problems: milk allergy	
Additional details:	

Child: BM	
Date of Birth	28-07-85
Age at interview:	79 months
Subject category:	COND (SCBU)
Tymp history:	yes
Tymp present:	no
Age seen at ENT clinic:	15 months
Status at time of interview	–
Intervention received for middle ear problems:	i. none ii. none iii. none
Other problems:	
Additional details:	

Child:RN	
Date of Birth	13-12-86
Age at interview:	62 months
Subject category:	COND (SCBU)
Tymp history:	yes
Tymp present:	–
Age seen at ENT clinic:	17 months
Status at time of interview	not specified
Intervention received for middle ear problems:	i. none ii. none iii. none
Other problems: poor speed/balance	
Additional details:	

LANGUAGE SCORES DERIVED FOR MOTHERS INTERACTING WITH HEARING-IMPAIRED CHILDREN AND USED IN REGRESSION ANALYSES (CHAPTER SEVEN)

SN1 – Language measures derived for the mother during the interaction session between mother and child. All measures correspond to the child's first 100 utterances, except vocabulary (VOC) which is derived from the mothers' first 100 utterances.

SN1	MOTHERS' LANGUAGE MEASURES								
SUBJECTS	UTTS (MOT)	MLU (MOT)	VOC (MOT)*	UTTS.MZ (MOT)	WDROOTS (MOT)	TUA (MOT)	WPM (MOT)	PQU (MOT)	PNV (MOT)
VR1	234	5.08	187	1	241	22	96	27	5
KH1	113	4.74	128	2	139	18	76	54	0
KWI1	83	4.88	157	2	141	12	54	53	0
TH1	134	4.29	51	4	80	17	68	63	0
WW1	179	3.73	117	11	155	18	63	10	4
CN1	249	4.42	149	1	231	22	85	33	1

continued

SN1	Mothers' Language Measures								
Subjects	UTTS (MOT)	MLU (MOT)	VOC (MOT)*	UTTS.MZ (MOT)	WDROOTS (MOT)	TUA (MOT)	WPM (MOT)	PQU (MOT)	PNV (MOT)
SB1	337	5.42	157	3	340	16	79	44	0
DA1	224	4.14	135	7	221	20	75	33	2
JA1	273	4.27	119	0	202	18	67	41	0
AA1	236	4.28	119	0	185	18	70	42	0
JCA1	130	4.56	145	0	179	11	41	39	0
KW1	107	2.72	80	4	84	16	37	25	5
TWH1	362	4.10	105	2	234	23	83	29	1
JH1	203	6.59	159	6	279	13	78	46	2
JCL1	142	6.32	180	6	217	13	76	35	1
Mean	200	4.6	133	3.3	195	17	70	38	2
S.D.	84	.96	36	3.1	70	4	16	13	2

* Vocabulary is based on corpus of 100 mother-utterances.

SN2 – Language measures derived for the mother during the interaction session between mother and child. All measures correspond to the child's first 100 utterances, except vocabulary (VOC) which is derived from the mothers' first 100 utterances.

SN2	MOTHERS' LANGUAGE MEASURES								
SUBJECTS	UTTS (MOT)	MLU (MOT)	VOC (MOT)*	UTTS.MZ (MOT)	WDROOTS (MOT)	TUA (MOT)	WPM (MOT)	PQU (MOT)	PNV (MOT)
JA2	115	5.03	143	4	153	5	22	23	0
AA2	84	5.38	143	2	136	4	20	25	0
SB2	186	4.52	143	4	213	11	43	25	3
NC2	123	3.82	95	0	109	10	35	37	1
JCR2	146	3.35	98	2	125	3	10	30	2
AFO2	157	5.22	161	10	211	22	104	45	0
MH2	142	5.77	145	1	167	13	67	55	1
MHO2	149	3.68	124	3	162	16	51	25	0

continued

SN2	MOTHERS' LANGUAGE MEASURES								
SUBJECTS	UTTS (MOT)	MLU (MOT)	VOC (MOT)*	UTTS.MZ (MOT)	WDROOTS (MOT)	TUA (MOT)	WPM (MOT)	PQU (MOT)	PNV (MOT)
JUNIPER2	140	5.64	146	6	177	16	80	38	0
AL2	268	4.59	144	9	243	14	59	32	4
METCALF2	107	4.86	132	5	136	11	50	44	0
MEAN S.D	161 59	4.8 .89	134 21	5.4 3.8	172 42	13 6	55 28	34 10	2 3

continued

SN2	MOTHERS' LANGUAGE MEASURES								
SUBJECTS	UTTS (MOT)	MLU (MOT)	VOC (MOT)*	UTTS.MZ (MOT)	WDROOTS (MOT)	TUA (MOT)	WPM (MOT)	PQU (MOT)	PNV (MOT)
SN2	120	3.84	91	2	104	13	47	38	1
AB2	85	5.48	162	8	140	9	45	39	4
AC2	304	5.18	133	6	234	24	109	33	1
AFL2	177	4.62	127	6	189	13	55	36	2
CC2	210	3.98	128	11	183	8	28	12	4
JMI2	205	4.89	137	4	204	19	81	38	1
RW2	175	6.96	158	14	217	14	85	38	10

* Vocabulary (mother) is based on corpus of 100 mother-utterances.

General Hospital

Children's Hearing Assessment Centre

Your Ref:

Our Ref:

Please Ask For

Park Row
Nottingham
NG1 6HA
Telephone: (0602) 412944

Dear

I am writing to ask you if you would be willing to take part in a research project which is being undertaken at the MRC Institute of Hearing Research at Nottingham University. The project concerns the language and communication of children who attend the Children's Hearing Assessment Centre.

If you agree to participate in the study, it will involve a visit to your home, by Tina Ramkalawan a researcher from the Institute of Hearing Research, on just one occasion. During this visit, she will make a video recording of you and playing together. In addition, a few tests of hearing and other skills (more like games really) will be carried out. She will need to stay for 2 to 3 hours at the most. A small payment of will be given to cover any inconvenience caused to you and your family.

I very much hope that you will agree to take part in this study as it is only through this kind of research that we may be able, in the long term, to help improve our understanding of, and services to, all children with hearing difficulties. However, the decision remains entirely yours you are under no obligation to do so,and if you do not wish to take part this will not affect the service you receive from this department in any way.

Please find enclosed a reply slip. I would be grateful if you could fill it in and return it in the enclosed envelope (no stamp needed).

If you have any queries whatsoever, please do not hesitate to telephone Tina Ramkalawan on Nottingham 223431 or me on Nottingham 412944.

With best wishes.

Yours sincerely

Sally Wood

Sally Wood
Principal Audiological Scientist

Enclosed.

Nottingham Health Authority

General Hospital

Children's Hearing Assessment Centre

Your Ref:
Our Ref:
Please Ask For

Park Row
Nottingham
NG1 6HA
Telephone: (0602) 412944

Dear

I am writing to ask if you would be willing to take part in a research project which is being undertaken at the Medical Research Council - Institute of Hearing Research at Nottingham University. The project concerns the language and communication of children. Part of the project involves visiting children who have visited the Children's Hearing Assessment Centre once only and were found to have no problems with their hearing.

If your agree to participate in the study, it will involve a visit to your home, by Tina Ramkalawan, on just one occasion. During this visit, she will make a video recording of you and ______________________ playing together. In addition a few tests of hearing and other skills (more like games really) will be carried out. She will need to stay for 2 to 3 hours at the most and a small payment of £25 will be given to cover any inconvenience caused to you and your family.

I very much hope that you will agree to take part in this study as it is only through this kind of research that we may be able, in the long term, to help improve our understanding of, and services to, children with hearing difficulties. However, the decision remains entirely yours and not wishing to participate will not affect any services you receive in any way.

Please find enclosed a reply slip. I would be grateful if you could fill it in and return it in the enclosed envelope (no stamp needed).

If you have any queries whatsoever, please do not hesitate to telephone Tina Ramkalawan on Nottingham 223431 or me on Nottingham 412944.

With best wishes.

Yours sincerely

Tracey Twomey

Tracey Twomey
Principal Audiological Scientist

REPLY FORM

Child's Name: . . . .

Address: . . . .

. . . .

. . . .

. . . .

Telephone number: . . . .

. . . .

Brothers/Sisters: yes/no

(if yes) Names of brother(s)/sister(s) and ages: . . . .

. . . .

. . . .

I would like/would not* like to participate in the study with the MRC Institute of Hearing Research.

your name . . . .

Signature: . . . .

Most convenient days and times to be contacted:

. . . .

. . . .

. . . .

---

* - please delete as required.

QUESTIONNAIRE (STUDY 1)

BACKGROUND

file *Name of child*

date *Date*

int *Name of interviewee*

mot.occ *Mother's occupation*

mot.ed *Mother's education*

fat.occ *Father's occupation*

fat.ed *Father's education*

sex *Sex of child*
1 = male
2 = female

age *Age of child at interview*

brothers *How many brothers does your child have?*

sisters *How many brothers does your child have?*

nursery *Is your child presently at nursery?*
1 = yes
2 = no

school *Is your child presently at school?*
1 = yes
2 = no

DETECTION & DIAGNOSIS

DD1 *Who first made you aware that your child might have a hearing problem?*
1 = your child
2 = yourself
3 = your partner
4 = health visitor or nurse
5 = doctor
6 = relative or friend
7 = teacher
8 = other

DD2 *When did you first suspect that your child might have a hearing problem?*
1 = soon after birth
2 = before 6 months
3 = 6–12 months
4 = 12–18 months
5 = after 18 months

DD3 *When was your child's problem first diagnosed?*
1 = before 6 months
2 = 6–12 months
3 = 12–18 months
4 = after 18 months

DD4 *Where was your child referred?*

DD5 *Who referred your child?*
1 = health visitor
2 = community physician
3 = paediatrics
4 = general practitioner
5 = other

DD6 *What was the reason for the referral? (fill DD6a–c as required)*
1 = failed 7-month HV screen
2 = parental concern
3 = professional concern
4 = delayed speech/language
5 = failed hearing test
6 = failed neonatal hearing test
7 = other
8 = passport follow up

DD7 *When was your child referred?*
1 = before 6 months
2 = 6–12 months
3 = 12–18 months
4 = after 18 months

AETIOLOGY

aetiol *What is the cause of your child's hearing loss?*

prevent *Do you feel your child's hearing loss could have been prevented?*

explain.1 *Who explained your child's hearing impairment to you?*

explain.2 *Were you satisfied with how this was done?*
1 = yes
2 = no

info.1 *What additional information would have been helpful at this time?*

Feelings Towards Diagnosis

feelings *How did you feel about the diagnosis?*

accept *What was most difficult to accept?*

told *How good were explanations about the problem treatments etc?*
1 = very thorough
2 = satisfactory
3 = not detailed enough
4 = quite insufficient
5 = completely insufficient

info.2 *Did you find out more for yourself? If so, where did you go?*

counsel *Did you get counselling?*
1 = yes
2 = no

type *What kind of counselling did you get?*

comm.1 *Was the counselling helpful?*

guilt *Did you have any feelings of guilt?*
1 = yes
2 = no

blame *Do you blame anyone for your child's hearing impairment?*

comm.2 *Have you come to terms with your child's hearing impairment?*

Services Provided

SP1 *What intervention / treatment(s), other than HAs, has your child received for his / her hearing loss? (fill SP15a–d as required)*
1 = peripatetic teacher
2 = speech therapy
3 = signing classes
4 = support within school
5 = other
6 = none

SP2 *Are you satisfied with these provisions?*
1 = yes
2 = no

SP3 *How good were explanations about the problem treatments etc?*
1 = very thorough
2 = satisfactory
3 = not detailed enough
4 = quite insufficient
5 = completely insufficient

SP4 *Does your child wear a hearing aid?*
1 = yes
2 = no

SP5 *Do you feel that your child is using his/her hearing aids effectively and that they are of some benefit?*
1 = yes, definitely
2 = to some extent
3 = to a very small extent
4 = not at all

SP6 *Do you encourage your child to wear hearing aids?*
1 = yes
2 = no

SP7 *Are there ways in which you feel your child's hearing loss could have been managed more effectively?*
1 = yes
2 = no

SP8 *Do you think early detection of deafness is important for children with hearing loss?*
1 = yes
2 = no
3 = not sure

SP9 *Additional comments?*

QUESTIONNAIRE (STUDY 2)

BACKGROUND

file *The name of the child*

int *Name of interviewee*

date The date of the interview

mot.occ *The mother's occupation*

mot.ed *The mother's education*

fat.occ *The father's occupation*

fat.ed *The father's education*

brothers *How many brothers does your child have?*

sisters *How many sisters does your child have?*

nursery *Is your child presently at nursery?*
1 = yes
2 = no

school *Is your child presently at school?*
1 = yes
2 = no

DETECTION & DIAGNOSIS

DD1 *Who first made you aware that your child might have a hearing problem?*
1 = your child
2 = yourself
3 = your partner
4 = health visitor or nurse
5 = doctor
6 = relative or friend
7 = teacher
8 = other

DD2 *When did you first suspect that your child might have a hearing problem?*
1 = soon after birth
2 = before 6 months
3 = 6–12 months
4 = 12–18 months
5 = after 18 months

DD3 *When was your child's problem first diagnosed?*
1 = before 6 months
2 = 6–12 months
3 = 12–18 months
4 = after 18 months

DD4 *Where was your child referred?*

DD5 *Who referred your child?*
1 = health visitor
2 = community physician
3 = paediatrics
4 = general practitioner
5 = other

DD6 *What was the reason for the referral? (fill DD6a–c as required)*
1 = failed 7-month HV screen
2 = parental concern
3 = professional concern
4 = delayed speech/language
5 = failed hearing test
6 = failed neonatal hearing test
7 = other
8 = passport follow up

DD7 *When was your child referred?*
1 = before 6 months
2 = 6–12 months
3 = 12–18 months
4 = after 18 months

DD8 *What was the date of your first appointment?*

DD9 *Details of any assessments / appointments elsewhere.*

DD10 *When was your child first fitted with hearing aids?*

DD11 *How long has your child been wearing hearing aids?*
1 = less than 6 months
2 = 6–12 months
3 = 12–18 months
4 = 18–24 months
5 = more than 2 years

DD12 *Do you feel that your child is using his/her hearing aids effectively and that they are of some benefit?*
1 = yes, definitely
2 = to some extent
3 = to a very small extent
4 = not at all

DD13 *When was the last time your child had a hearing test?*
1 = less than 3 months ago
2 = 3–6 months ago
3 = 6–12 months ago
4 = more than 12 months ago
5 = can't remember when

DD13.com *What was the result?*

DD14 *Does you child's hearing ability seem to get better or worse for at least several days at a time?*
1 = yes, it has good and bad patches
2 = no, it is constant
3 = not sure

DD15 *What intervention / treatment(s), other than HAs, has your child received for his / her hearing loss?*
1 = peripatetic teacher
2 = speech therapy
3 = signing classes
4 = support within school
5 = other
6 = none
fill DD15a–d as required

DD16 *Are you satisfied with these provisions?*
1 = yes
2 = no

DD16.com *Any comments on provisions?*

DD17 *Does your child have any problems apart from his/her hearing loss?*
1 = yes
2 = no

DD18 *If yes, what sort of problems?*
1 = behaviour problems
2 = interaction with teachers / leaders
3 = attention concentration
4 = other
5 = no problems at all
fill DD18a–c as required

DD19 *Has your child ever had runny ears / glue ear?*
1 = yes
2 = no
3 = not sure

DD20 *If yes, what treatment, if any, has he / she received for this?*
(fill DD20a–c as required)
1 = none
2 = referred for surgery, DNA
3 = referred for surgery, attended, not done
4 = antibiotics
5 = gromments – bil / uni
6 = myringotomy – bil / uni
7 = adenoidectomy
8 = tonsilectomy
9 = hearing aids
10 = other

DD21 *Is there a family history of hearing problems?*
1 = yes
2 = no
3 = not sure

DD22 *If yes, what types of problems?*

DD23 *How concerned are you about your child's ears / hearing at present?*
1 = very concerned
2 = moderately concerned
3 = not concerned at all

DD24 *Was your child tested for hearing loss soon after birth (ie neonatally screened)?*
1 = yes
2 = no
3 = not sure

General Health

GH1 *Was your child born full term or premature?*
1 = full term
2 = premature

GH2 *If premature, by how many months?*

GH3 *Did your child spend any time in the SCBU?*
1 = yes
2 = no

GH4 *How long did your child spend in Special Care?*
1 = less than 1 month
2 = 2–3 months
3 = 3–6 months
4 = 6–12 months
5 = more than 12 months

GH5 *Were there any other problems?*
1 = yes
2 = no
3 = not sure

GH6 *If yes, what type of problems?*

GH7 *How often has your child been to the family doctor in the past year for other ailments?*
1 = not at all
2 = once
3 = 2–4 times
4 = 5–9 times
5 = 10 times or more

GH8 *If more than once, what sort of ailments have these visits been for?*

GH9 *Has your child been in hospital, since birth, for any other long term illnesses or problems?*
1 = yes
2 = no
3 = not sure

GH10 *If yes, what sort of illnesses or problems?*

GH11 *Has your child got any other problems from the following list?*
1 = behavioural problems
2 = balance or coordination problems
3 = visual problems or squint
4 = mental disorders
5 = dysmorphology
6 = SN deafness
7 = others, eg epilepsy, paralysis, heart murmur, etc.
8 = no problems

GH12 *Do any of your child's brothers or sisters have hearing or ear problems? (fill GH12a–c as required)*
1 = frequent earache
2 = runny ears
3 = permanent SN HI
4 = fluctuating (conductive) HI
5 = other hearing problems
6 = siblings have no problems
7 = child has no siblings

Language & Communication

LC1 *Are you happy with your child's language development at present?*
1 = yes
2 = no
3 = not sure

LC2 *If not, why aren't you happy?*

LC3 *Has there ever been a time when your child's language development has concerned you?*
1 = yes
2 = not really
3 = definitely not

LC4 *If yes, when was this?*

LC5 *How would you say your child mainly communicates?*
1 = speaks in sentences
2 = strings two words together frequently
3 = using one-word utterances
4 = usually indicates what he / she wants by some other means, eg gesture or sign
5 = some combination of the above

LC6 *Most typically, how does your child get your attention?*
1 = calls out to you
2 = vocalizes and waves hands
3 = touches or grabs you
4 = other

LC7 *Do you feel you understand what your child is saying or wants more easily than other members of the family?*
1 = yes
2 = no
3 = sometimes

LC8 *Do you feel that people unfamiliar to your child find it difficult to interpret what he / she is trying to say?*
1 = yes
2 = no
3 = sometimes

LC9 *If yes, in what situations have you noticed such difficulties?*

LC10 *Do you think your child finds it difficult to understand what you are trying to say to him / her?*
1 = a lot of the time
2 = on some occasions
3 = on very few occasions
4 = not at all

LC11 *Have you found it necessary to modify the way you speak to your child to make it easier for him / her to understand you?*
1 = yes
2 = no
3 = occasionally

LC12 *If yes, in what way(s) do you modify your manner of speaking?*
1 = speak more slowly
2 = speak louder
3 = repetition with increased visual contact
4 = combination of the above
5 = none of the above
6 = other

LC12.com *Comments on ways of modifying?*

LC13 *When you modify the way that you speak, is communication easier?*
1 = yes
2 = no, not really
3 = sometimes
4 = a little

LC14 *How often do you and / or your partner and your child read together, play together, etc?*
1 = frequently (at least once a day)
2 = often (once every couple of days)
3 = quite often (a couple of times a week)
4 = occasionally
5 = very rarely

LC15 *If your child is in school or nursery, is the teacher or group leader aware of your child's hearing problem?*
1 = yes
2 = no

LC16 *Has the teacher or group leader reported any problems with...?*
1 = behaviour
2 = interacting with teachers / leaders
3 = interacting with other children
4 = attention / concentration
5 = no such problems reported

Services Provided

SP1 *Are you satisfied with the way things were handled by the services after your child's hearing problem was detected?*
1 = completely satisfied
2 = moderately satisfied
3 = not very satisfied
4 = completely dissatisfied

SP2 *If not, how could things have been improved?*

SP3 *Do you feel your child's problem was dealt with as quickly and as efficiently as possible?*
1 = yes
2 = no
3 = not sure

SP3.com *If not, why not?*

SP4 *How good were explanations about the problem, treatments etc?*
1 = very thorough
2 = satisfactory
3 = not detailed enough
4 = quite insufficient
5 = completely insufficient

SP5 *Are there ways in which you feel your child's hearing loss could have been managed more effectively?*
1 = yes
2 = no

SP6 *Do you think early detection of deafness is important for children with hearing loss?*
1 = yes
2 = no
3 = not sure

SP7 *Additional comments?*

SAMPLE EXTRACT OF TRANSCRIPT
FROM SALT (18 MINUTES)

$Child, Mother, Sister, Interviewer
+Environment is the child's own home
-00:00:00
M what did she do?
C it/'s walk/ing them up.
C in my shoe.
M in your shoe?
C in my shoe.
M where/'s Tibby go/ing?
M where/'s he go/ing?
C in down there.
M right down?
M <does he like it>? *overlapping speech < >*
C <XXX>. *unintelligible speech xxx*
C there/'s Tibby.
M there/'s Tibby.
C there/'s Tibby.
C a picture.
C picture Tibby, picture.
M is she play/ing hidey? *bound morpheme /ing*
M what/'s she play/ing?
C picture.
J (I) (I can) I got Tibby on my picture.
C you can/'t show him turn/ing round.
C oy Tibby want/3s his picture. *bound morpheme /3s*
M who/'s got black on their tongue?
M Katie.
C what.
M who/'s got black on their tongue?
M who?
M oh you.
;5 minutes *pause*
C <argh>.
M what do you think of grandad/z parrot?
M the lady does/n't know about grandad/z parrot.
M what colour is he?
C green and yellow *and blue.
M green and yellow and blue?
S <look at the camera when you/'re saying it>.
M <what else>?
C and red.
M yes.
M it/'s got some red.
C and brown eye/s.
M yes.
S he has/n't got brown eye/s.
M he has round his eye/s.
S oh I did/n't notice that.
M mhm, yeh.
M and what else?
M what else can we tell the lady about him?
S (did I) <did the parrot XXX XXX>?

M <what does he eat for his dinner>?
M what does baby eat for his dinner?
C apple and grape/s.
M apple and grape/s.
M what else?
C (umm) apple/*s *and pear/s.
M pear/s.
M <and>.
C <and> banana/s.
M what does grandad cook for him?
C egg/s.
M egg/s.
M and what doe/3s he do?
C and he put bread in <the parrot>.
M <he puts the bread in his> claw and he dips it in the egg and he go/3s %omm.
C he/'s eaten the bread.
M he eat/3s the bread, not the egg but the yolk, does/n't he?
C and the egg.
M yes.
S did baby bite my finger?
C yeh.
C she got (one two three) four.
M claw/s.
M has he?
M I/'ve not look/ed.
M perhaps he has.
C what/'s that mum?
M what/'s that?
M that/'s the microphone to talk into.
J do you want to pin it to you?
C yep.
M he/'s got one.
;
S <who/'s Oink>?
C <his> name is Oink, he/'s got white hair.
C <and Patch>.
S <what colour is he>?
C and Patch>
M XXX.
C Oink got red eye/s.
M yes, he/'s got red eye/s and white <fur>.
C <and>.
C Patch got brown hair.
C what colour/'s the eye?
M I think they/'re dark black, black or brown, <dark very dark>.
S <(Katie has he got)>, has he got orange on him aswell?
S orange, he/'s orange.
S <and he/s black>.
C <(which is) what colour/'s on> his eye?
S they/'re black.
M and what are they?
C don't know.

C they/'re my Oink and Patch.
M yeh what sort of animal/s are Oink and Patch?
M go and get them Becci.
S me?
M yes please.
M what sort of animal/s are Oink and Patch?
C got to put chick/s in, Oink *and Patch.
M what are they?
C don't know.
M are they rabbit/s?
C dead.
M ooh the rabbit/'s dead, yes that was wrong for me to say.
M (umm is it) are they dog/s?
C mum.
M are Oink and Patch dog/s?
C mum?
C mummy (you know) you know Pat brought Oink and Patch. *maze*
M yes.
M Pat brought them yes.
M and what are they?
C mummy.
C Pat/'s got lots and <lots>.
M <no>.
C guinea pig/s.
C mum.
C Pat/'s got lots and lots of guinea pig/s.
M guinea pig/s yes.
M and Patch and Oink were only baby/s were/n't they, when we had them?
C no.
M they were small.
C he grown fat.
M he has grown fat yes.
C too much dinner.
M yeh I think it/'s probably too much dinner.
C eat dinner.
M {laughs}.
C now eat your/z.
C that/'s your/z.
C she/'s eat/ing.
C Patch eat Oink/z apple/s.
M oh he did/n't?
M <he/'s greedy>.
C <he could/n't find it>.
M could/n't he find it?
M oh well that/'s why then.
M watch your finger/s.
C ow!
M watch your finger/s because he does/n't know what/'s apple and what/'s finger when it smell/3s of apple/s.
M Katie!
C what?
M listen.

M he does/n't know.
M if your finger/s smell of apple he will think its apple and he/'ll bite it.
C he go/ing to eat XXX get on.
M <that/'s right>.
J <yes>.
M I would.
C oh.
M he/'s nearly ate it.
M he/'s a greedy boy.
C he go/3s (%a %a %a %a %a) %a.
M is that what they/'re (do) do/ing?
M what cartoon did you watch at school then?
C in the hall.
M in the hall?
M and what was it?
C ooh.
C cartoon.
M yes, and what was it about?
C big mummy dog/'s white little baby dog.
M and were they white dog/s?
C no yellow one.
M yellow one?
C and a brown one.
C she got spot.
M ohh.
M and did someone take the puppy/s away?
C no the puppy/s going to bed.
M did they?
C yeh.
M and did the mummy go to look for them?
C yeh.
C here y/'are.
C (Patch) Patch!
C come on eat your apple.
C eat your apple.
C don't eat Oink/z apple.
C and there/'s your apple.
C she/'s eatin* it in a minute.
C you got to eat it.
C she don't want it.
C Oink that/'s your apple.
C that/'s your apple.
C (urr) that/'s your apple.
C she eatin* it now.
C here y/'are Oink.
C come.
C here y/'are.
C don't eat Patch apple {pointing finger at Oink}.
C okay?
C stop it.
C (no no) no eat your apple Patch.
C that/'s your apple.

M are they being good now?
C yeh.
-18:12:00

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The effects of hearing loss and age of intervention on some language metrics in young hearing-impaired children

T. W. Ramkalawan and A. C. Davis

MRC Institute of Hearing Research, University of Nottingham, University Park, Nottingham NG7 2RD, UK

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Abstract

This study examined the oral language production abilities of a group of young children with bilateral sensorineural hearing impairments (>25 dB HL). The effects of age of intervention – as indexed by age of detection, referral, first appointment and hearing-aid fitting – and of the severity of their hearing impairments on spoken language and communication were the foci of the study. Children were aged between 27 and 80 months with hearing threshold levels ranging from 32 to 98 dB in the better ear. All were audio- and video-taped in their own homes, in an unstructured play setting with the mother. Measures of expressive language ability were extracted including mean length of utterance, vocabulary size, words per min., total utterance attempts per min., proportion of non-verbal utterances and the proportion of questions asked by the child. No significant correlations were found between the children's hearing impairments and their scores on the language measures once age at interview had been statistically controlled. However, significant correlations were found between the language measures and the ages at which the children received intervention for their hearing impairments, in particular for vocabulary and those language measures denoting the rate and quality of the child's interaction during the episode recorded. This finding is consistent with some of the arguments to be found in the small body of data addressing the question of early intervention.

Introduction

The reduction in acoustic input and feedback for the congenitally or prelingually hearing-impaired child, places him/her at considerable disadvantage for acquiring spoken language, as has been documented by several studies (Erber, 1983). However, most of the studies investigating the effects of hearing impairment on language have tended to concentrate on the speech patterns and language comprehension of older children with severe or profound losses (>85 dB HL) (Markides, 1983; Quigley *et al.*, 1974, 1977) or, more recently, on the developmentally complex and linguistically rich properties of sign language (American Sign Language) in hearing-impaired children (Pettito, 1983).

From the few studies which have endeavoured to look at the emergence of spoken language/communication in young hearing-impaired infants, there is consistency in the observation that patterns of development can be similar to those seen in normal infants, yet delayed (Gregory, 1983). However, most of these studies consist of small numbers of severely and profoundly hearing-impaired children, while little work to date has looked specifically at spoken language in children with mild and moderate hearing impairments (between 25 and 65 dB HL).

Several investigators have highlighted that auditory differences even between children with severe and children with profound losses can have considerable bearing on the efficacy of specific methods of rehabilitation and types of amplification aimed at helping the child to acquire spoken language (Kretschmer and Kretschmer, 1978). It is important to evaluate the differences in efficacy of such rehabilitative regimes as applied to those children with mild/moderate hearing impairments as well as those with severe/profound losses.

One aim of the study presented here was to document the effects of hearing loss on expressive spoken language ability across an extended range

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of hearing impairments, to include mild and moderate as well as severe impairment.

In addition, foreseeable advances in acoustic and electro-physiological methods of screening for hearing loss mean that congenital hearing impairments are potentially detectable from 24 h of age (Sancho *et al.*, 1988; Davis and Sancho, 1988). It is feasible therefore that a larger proportion of those children suffering from mild/moderate losses could be detected at very early ages, along with those with more severe losses. The age of detection appears to be important in determining outcome for those children with profound hearing losses, although quantitative evidence is still somewhat scarce (Markides, 1986). It would be useful to show that early detection for *any* hearing impairment, not just the profound losses, could be beneficial for a child, even if the degree of benefit varied with the severity of hearing impairment. Subsequently, this might lead to earlier intervention, in the form of acoustic amplification, where applicable, and exposure to educational programmes encouraging maximal use of residual hearing and the development of language (in whichever modality is judged most appropriate for the individual child in question). Indeed it has been implied that many of the psychologically and socially detrimental and debilitating effects of 'deafness' can be alleviated if children are taught to utilize any residual hearing, or even vibrotactile sensitivity, before critical periods of language acquisition, thought to be within the first 6 months of life (Guinagh and Jester 1981; Markides, 1983, 1986). Another aim of this study was to look at the effects of early detection and intervention on the expressive oral language ability of hearing-impaired children, particularly those with mild to severe (25–95 dB HL) losses.

Our cross-sectional study's objective, once the appropriateness of the methodology had been established, was to investigate whether there were any systematic variations in language as a function of (a) the severity of the children's hearing impairments and (b) age of intervention. It was anticipated that both variables would be inversely related to the language outcome measures (i.e. the language metrics).

Method

Language metrics

Several approaches to the measurement of language exist; these and the choice of language metrics are discussed in the appendix. The six language metrics chosen in three categories were: (i) basic measures of syntactic complexity – mean length of utterance in morphemes (MLU) and the size of the child's vocabulary (VOC); (ii) measures pertaining to the child's rate of interaction – total utterance attempts per min. (TUA) and number of words spoken per min. (WPM/WDPM); and (iii) measures related to communication clarity and discourse – proportion of questions asked by child (PQ) and proportion of nonverbal utterances (PNV). Subjects' MLU scores were also plotted against a template of normative data (Wells, 1985) for comparative purposes.

Subjects

All subjects were chosen from records at the Children's Hearing Assessment Centre (CHAC) at the General Hospital in Nottingham. Forty-eight children were chosen on the premise that they had no severe handicap in addition to their hearing impairment. Letters informing these families of the study and inviting them to take part in it were distributed. Of the initial 48 families approached, 20 (42%) agreed to take part in the study; their 20 hearing-impaired children (ten boys and ten girls) comprise the subjects entering the study. The families who did not reply to the initial invitation were not re-invited to participate. Upon comparison, the children who took part in the study did not differ statistically in age, sex, or mean hearing level in the better ear from those who chose not to take part. Table I shows the ages and hearing threshold levels for the children. Nineteen of the subjects had bilateral congenital hearing impairments, and one had a bilateral early acquired prelingual impairment (subject WW). All had hearing parents and had spoken English as their first language.

Four of the profoundly hearing-impaired children (three boys and one girl) were excluded from all language analyses presented here, either because their main mode of communication was sign language, or because of an absence of sufficient verbal output for the purpose of the study at this stage. Questions pertaining to the needs of children with low verbal output are of course important and need to be addressed, but these extended beyond the purpose of the study presented here.

For the 16 children whose linguistic assessments are presented here, Table I shows that the age range was 27–80 months and that hearing impairments ranged from 32–98 dB HL (mean = 62 dB HL) in the better ear averaged over the frequencies 500 Hz, 1 kHz, 2 kHz and 4 kHz. Hearing assessments were all conducted at CHAC and thresholds were determined by means of pure tone audiometry where the children were of sufficient age. Alternatively, Performance, Co-operation, Distraction and/or Visual-Reinforcement tests of hearing were used to ascertain thresholds for the younger children. All the children in the study had been using bilateral hearing aids for an average of 28 (s.d. 19) months.

Table I. Subjects of the study, their ages and hearing threshold levels (averaged over 0.5, 1, 2, 4 kHz) in the better ear (BEA). The means and s.d.s are given overall and for the 16 subjects who were subsequently analysed separately. Age of intervention in months illustrated by: age of child when hearing loss first detected (age detn), age of child when referred for treatment (age referral), age of child at time of first appointment (age 1st appointment) and age of child when hearing aids fitted (age fitting)

Name	Sex	Age (months)	Age detn	Age referral	Age 1st appointment	Age fitting	BEA (dB HL)	
BB	boy	15	7	7	7	8	100	*excluded*
SW	girl	33	10	11	11	12	95	*excluded*
AH	boy	61	1	1	2	3	117	*excluded*
LM	boy	62	4	7	8	9	105	*excluded*
IF	boy	27	12	11	11	16	55	
TW	boy	32	9	10	11	27	74	
JA	girl	38	8	13	14	33	52	
KC	girl	48	2	2	2	18	81	
VR	boy	54	8	10	11	16	40	
CN	boy	54	30	39	41	42	48	
JH	girl	57	4	9	9	11	98	
AA	boy	58	30	33	34	36	61	
SB	girl	61	18	37	38	39	68	
KW	girl	61	35	44	44	44	40	
JC	girl	66	14	14	16	17	78	
TH	girl	67	36	37	43	44	32	
WW	boy	69	36	48	52	54	80	
DA	boy	73	4	9	11	27	58	
KH	girl	74	6	7	13	18	65	
JCI	girl	80	13	13	13	22	72	
	mean	55	15	19	20	26	72	***All***
	s.d.	16	12	15	16	14	27	***subjects***
	mean	57	17	21	23	29	62	***16***
	s.d.	16	13	16	16	13	19	***subjects***

Four independent measures of 'age of intervention' were taken for each child. Table I presents the age of the child, obtained from CHAC records, (1) at the time hearing impairment was first suspected/detected, (2) at the time of referral, (3) at first appointment and (4) at the time of hearing-aid fitting. The means are shown for all 20 subjects and for the subset of 16 whose results are analysed below.

Materials

A Panasonic S-VHS video camera was used with VHS SE-180 cassette tapes for all recording purposes. In addition, audio recordings were made of the sessions using a Sony stereo cassette recorder with input through a Beyer radio microphone using calibrated recording levels. For transcription, a Panasonic NV FS1 VHS video recorder and a Sanyo audio transcriber were employed. All information from the sessions was transcribed and coded within the Systematic Analysis of Language Transcripts (SALT) programme by one transcriber (TR).

Procedure

Children were visited once in their own homes by the same interviewer. At all times the child was seen with the major care-giver, in all instances the mother. The camera and audio equipment were set up for recording; meanwhile, the child became familiar with the interviewer and the situation. The interviewer asked the mother about the child's communicative skills using the Pragmatics Profile of Early Communication Skills interview format (Dewart and Summers, 1988), and recorded the responses. This stage lasted approximately 45 min. Another short questionnaire was also completed concerning the mother's attitude to the services provided for the family prior and subsequent to the confirmed diagnosis of the child's hearing impairment. The final session consisted of approximately 35 min. of unstructured play involving the interviewer, the mother, child and other siblings when they were present. During the session, the participants would usually engage in shared reading and/or the playing of games. The mother and child were free to decide what to do during this time. From this period of unstructured play a sample of the study-child's language was drawn for analysis. Every child produced at least 100 consecutive utterances.

Whilst realizing that recording on a single occasion might render results which are unrepresentative of a child's normal linguistic capacity, care was taken to establish that any sample obtained was reasonably representative of the child's performance on other occasions. This was achieved by playing back the session to the mother and asking whether it was a 'typical' interaction or whether the child was more inhibited or active than usual.

Transcription

All samples were transcribed using both audio and video players. The video recordings served to provide context and to resolve ambiguities in the audio recordings. The utterances of all participants were coded into the SALT (Miller and Chapman, 1984; revised 1991) computer programme for analysis. SALT was developed at the Language Analysis Laboratory of Wisconsin, its prime aim being 'to analyse the communicative attempts of one or more speakers during an interaction'.

Within the SALT coding system, embedded morphemes (suffixes only) were stringently coded for all speakers, and all non-verbal actions were described. In order to be coded as an embedded morpheme, suffixes had to be representative of one of the following main categories (as specified by SALT): plurality (-s, -es); possessive inflections (-s, -'s, -s'); third person singular verb form (-s, -es); verb tense inflections (-ed, -d, -ing) or contractions/deletions (-'m, -'s, -'ll, -'re, -'ve, -n't, -'t). Irregular verb forms, gerunds and adjectival bound morphemes were not coded. In addition, occurrences of false starts, repetitions or reformulations on the part of the speaker were classified and coded as 'mazes'. Mazes were excluded from the calculation of mean length of utterance, WPM and vocabulary.

Non-verbal communication and gestures were also derived from video recordings and described within SALT. Occurrences of non-verbal utterances included all occasions when the child used gestural or facial expression in place of a spoken utterance/response. All verbal utterances which the transcriber considered to be intentionally interrogative on the part of the speaker were coded as questions and were generally recognised as such when the utterance contained 'question intonation', a tag or auxiliary verb. Timing information, pertaining to the length of the transcript in minutes and seconds, was also included at the beginning and end of each session transcript. Pauses between and within speaker utterances were also indicated, although precise timings of these were not necessary for the extraction of required language measures.

Language metrics

The six measures: MLU, VOC, TUA per min., WPM/WDPM, PNV and PQ are shown in Table II. An additional measure of the number of words per minute [the product of TUA and MLU (in words)], WDPM, was calculated externally to SALT. This measure differed from the WPM produced by SALT, because SALT's calculation of MLU (words) includes those words contained within mazes. WPM, calculated by SALT, excludes words located within mazes.

All these measures were also obtained for the care-givers who interacted with the children during the session. This provides data pertaining to the linguistic input received by the child during the session and the patterns of communication arising between care-giver and child. These data are the subject of a future paper.

A measure of the socio-economic group (SEG) was derived from the occupation of the head of the household for each family involved in the study. SEG was represented by categories 0–4, in which 0 = unemployed, 1 = professional/managerial occupation, 2 = semi-professional/clerical occupations, 3 = semi-skilled occupations, and 4 = unskilled occupations. This corresponds to the codes outlined in the UK Registrar-General's Classification for Socio-Economic Group (OPCS, 1980).

Results

It was important to establish at the outset that there were no important methodological problems due to the cross-sectional nature of our interview schedule, or to the presence, in some cases, of other children during recording. Firstly, separating each child's transcript into two halves showed no substantial fatigue or warm-up effects over the course of the recorded episode. Secondly, there was no significant main effect on subjects' language measures as a result of having another child present during the recorded play session. A comparison of all seven language metric means, between children who had siblings present and those who did not, showed no significant differences ($P > 0.10$). The means and standard deviations for the language metrics are shown in Table II.

There are several ways to investigate the effects of *hearing threshold level* and *age of intervention* on the language scores. In this instance, multiple regression was used to model these effects, and the partial correlations presented in Table III were

Table II. The scores obtained by the children on the language measures used ordered by the age of the child at the time of interview: MLU, VOC, PNV, PQ, TUA and WDPM/WPM. SEG is also presented (see text). Average hearing threshold in the better ear in dB HL (BEA) is also given

Name	Age (months)	SEG	BEA	MLU	VOC	PNV %	PQ %	TUA	WDPM	WPM (SALT)
IF	27	1	55	1.1	4	83.5	0.0	3.8	4.2	0.7
TW	32	4	74	1.2	29	36.7	3.3	6.7	8.2	5.3
JA	38	2	52	2.9	184	0.5	4.2	6.5	18.9	17.7
KC	48	4	81	1.9	171	21.9	7.1	16.7	31.0	24.4
VR	54	2	40	3.3	182	15.0	6.4	9.4	30.7	25.5
CN	54	4	48	2.3	294	2.1	1.7	10.4	23.4	22.5
JH	57	1	98	4.3	264	6.9	7.3	6.3	26.9	23.6
AA	58	2	61	3.3	147	1.2	2.4	8.2	26.9	24.8
SB	61	4	68	2.6	173	13.2	3.7	5.5	14.7	12.3
KW	61	0	32	2.0	147	4.1	7.7	8.6	17.5	15.8
JC	66	4	78	2.2	317	1.2	10.6	11.9	25.6	23.8
TH	67	0	32	2.3	194	0.4	3.5	12.7	28.8	27.7
WW	69	3	80	2.8	150	4.3	10.1	10.0	28.1	25.3
DA	73	0	61	3.1	252	4.0	7.6	9.0	28.0	26.2
KH	74	2	65	3.0	233	3.0	12.6	16.2	48.7	45.5
JCI	80	3	72	4.1	242	15.6	11.3	10.3	42.8	33.4
Mean	57	—	62	2.7	186	13.3	6.2	9.5	25.3	22.2
s.d.	16	—	19	0.9	85	21.1	3.7	3.6	11.3	10.5

extracted from these analyses. Partial correlations are presented between the language scores and severity of hearing impairment, and between the language scores and age of intervention, controlling for age at interview. This is the simplest way to present the data for the purposes of this paper.

Age at interview and ages of intervention

The age of the child at the time of interview was a predictor for all language outcome measures ($P < 0.01$), this being indicative of the usefulness of the metrics employed. In all subsequent analyses age at interview was statistically controlled when deriving correlations of interest. Table III shows that the ages of intervention – represented by four independent measures of the age of the child at (1) detection, at (2) referral, at (3) first appointment and at (4) hearing-aid fitting – all had significant partial correlations ($P < 0.05$) with the number of words per minute (ranging from −0.46 to −0.59), with the proportion of questions asked by the child (ranging from −0.44 to −0.52) and with the vocabulary of the child (ranging from −0.45 to −0.51). The proportion of questions asked, the proportion of non-verbal utterances and the MLU, expressed as MLU/5, were also analysed using the arcsin root transformation of these variables and

Table III. Partial correlations found between the language measures and (i) ages of intervention (i.e. age of detection, referral, 1st appointment, hearing aid fitting) and (ii) hearing threshold level in the better ear, controlling for age at interview. For vocabulary (VOC) a quadratic function in age was used to control for age at interview

	Ages of intervention (months)				Hearing threshold level
	Detection	Referral	1st appointment	Fitting	
MLU	−0.36	−0.29	−0.33	−0.33	+0.28
TUA	−0.17	−0.30	−0.26	−0.19	+0.00
WPM	−0.37	−0.48*	−0.43*	−0.38	+0.05
WDPM	−0.47*	−0.60*	−0.56*	−0.50*	+0.15
PNV	−0.18	−0.25	−0.25	−0.35	+0.12
PQ	−0.53*	−0.55*	−0.54*	−0.48*	+0.46*
VOC	−0.47*	−0.49*	−0.48*	−0.46*	+0.24

* $P < 0.05$, $N = 16$, df = 13.

yielded slightly higher correlations. All correlations were negative: the lower the age of intervention the better the outcome measures for language were found to be. Most highly correlated with these language measures was the variable 'age at referral'.

A complementary approach to looking at 'age at referral' and 'age at interview' was to examine the amount of time that had elapsed between the child being referred for assessment and the time of interview, i.e. time since referral (see Table IVa). Regression analyses, using 'age at referral' and 'time since referral' highlighted the importance of these variables on all the language scores but most especially for WDPM and PQ (shown in Table IVa). For these language metrics, 'time since referral' appeared to be the most influential variable, with 'age at referral' being significant but less influential. However, in a retrospective and cross-sectional study of this kind, it is extremely difficult to interpret these regression coefficients. Correlations between age of intervention and MLU and PNV were found to be non-significant, but were all in the expected direction.

Hearing threshold level

Hearing threshold level was found to be significantly correlated to only one of the language variables (PQ), and the sign of this correlation was not in the expected direction. These partial correlations are presented in Table III. Taking the two highest correlations of hearing threshold level, with the proportion of questions and MLU, the sign of correlation is such that a higher degree of hearing impairment could be associated with better language scores. This is counter to the hypothesis initially proposed. The partial correlations only control for the effect of age at interview on the language measures, and no attempt is made to control for age at intervention. The joint effect of age at intervention and hearing threshold level can be examined in the multiple regressions shown in Table IVb. Here, the age of intervention is approximated by the age at referral. The age parameters are given per 10 months and the hearing threshold level parameter is given per 10 dB HL. For the vocabulary measure, a quadratic in age at interview gives the best fit. The age at interview has a large significant parameter estimate for all language measures. The age at referral always has the next most substantial effect using a coefficient of variation criterion. This parameter makes significant contribution to the WPM, proportion of questions and the vocabulary measure (when a quadratic age at interview function is used). The hearing threshold level parameter is always very small. For the 'proportion of questions' measure, where the mean/s.e. criterion is best and where the highest partial correlation is shown in Table III, a shift of 70 dB is equivalent to only 10 months of age at interview.

In summary, hearing threshold level within this refined sample, who had been using hearing aids for in excess of 2 years on average, did not substantially affect the language measures, but age at referral did.

Table IVa. Parameter estimates (standard errors) for the language measures WDPM and PQ, derived from the multiple regressions using the measures of age at referral and time since referral

	Age at referral	Time since referral
WDPM	0.010 (0.005)*	0.020 (0.004)*
PQ	3.6 (1.3)*	6.4 (1.0)*

* $P < 0.05$, $N = 16$.

Table IVb. Parameter estimates (standard errors) for the language measures, derived from the multiple regressions using the independent measures of age at interview, age at referral, and degree of hearing loss in the better ear

	Age at:			
	Interview quadratic	Interview (10 months)	Referral (10 months)	Hearing threshold level (10 dB)
MLU	—	0.38 (0.13)	−0.10 (0.14)	0.08 (0.11)
TUA	—	1.35 (0.59)	−0.75 (0.62)	−0.24 (0.50)
WPM	—	6.14 (1.11)	−2.34 (1.16)*	−0.60 (0.94)
WDPM	—	6.52 (1.14)	−3.04 (1.20)*	−0.43 (0.98)
PNV	—	−0.090 (0.030)	−0.020 (0.030)	0.00 (0.03)
PQ	—	0.020 (0.004)	−0.007 (0.004)*	0.004 (0.004)
VOC	−15.6 (6.6)	208.52 (7.21)	−19.19 (11.4)*	0.45 (0.87)

* $P < 0.05$, $N = 16$.

Social class effects

The effects of some possibly confounding covariates were also looked at, the most important being the SEG to which the family of the child belonged. The major effect of SEG was found in the MLU measure, with children of parents belonging to groups 1, 2 and 3 (professional, intermediate, and skilled occupations) consistently producing MLUs greater than those of similar age with parents in occupation groups 4 and 0 (semi/unskilled occupations and unemployed). However, taking SEG into account does not alter the pattern of results found above between age of intervention, hearing threshold level and the language metrics in Tables III, IVa and IVb.

Unfortunately, we did not have the opportunity of collecting data on a control group of 'normal' hearing children. Also normative data on the range of language variables used here are not available for children in the UK. However, normative values for MLU scores can be deduced from available literature. Therefore MLU scores for the children in our study were compared with a template of normative MLU values taken from data obtained by Wells (1985) in a large-scale longitudinal study which looked at language development in preschool children. His template of mean MLUs was calculated from 18 90-s samples of spontaneous spoken language collected for a sample ($N = 125$) of 'normal hearing' children. When plotted, most of the scores for our children were found to fall between the mean and minus 2 s.d., but as can be seen from Figure 1, many perform worse than the lower percentile values achieved by the normal children. There are several reasons why this might be the case, some due to obvious methodological differences and others presumably related to the lack of auditory input in combination with other factors, amongst them age of intervention.

Discussion

The comparison of MLU scores suggests that, at this stage in language development, MLU for our hearing-impaired children was substantially below that of normally hearing children. The anomaly with our results is that none of the language measures was apparently related to the severity of the children's hearing impairments over the mild to severe range.

Other studies have similarly reported a lack of direct significant influence of degree of hearing impairment on expressive and receptive spoken language abilities for children in this age group (Geffner, 1987). This suggests that for a wide range of hearing threshold levels, appropriately aided and counselled, there is no differential effect, at this stage, on the children's spoken language ability.

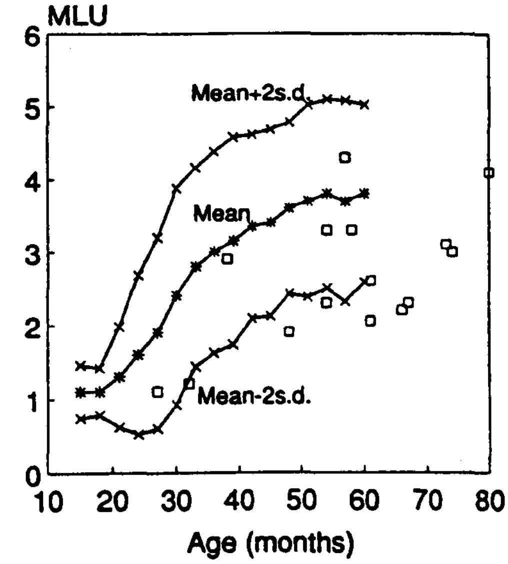

Fig. 1. MLU of the sample [□] *plotted on a template derived from Wells (1985) with the mean MLU* [•], *and the mean plus 2 times the s.d. and minus 2 times the s.d.* [×].

There can be little doubt that, had data from children with profound hearing impairments been included/evaluated, the picture would have been altered somewhat.

However, the significant correlations obtained between our independent measures of age of intervention and the child's performance on some of the language metrics imply that detecting and aiding a child's hearing impairment early holds advantages for the future development of certain aspects of spoken language. This agrees with White and White (1987) who found that hearing-impaired children of hearing parents, who had received intervention early (before 18 months of age) as opposed to late (after 18 months of age), performed consistently better on a range of receptive, as well as expressive, language tests. From the language measures looked at here, VOC, WPM/WDPM and PQ were the three measures upon which age of intervention (most especially age of referral) appears to exert the strongest influence. This suggests that children receiving early intervention for their hearing impairments have more diverse vocabularies and faster rates of discourse, i.e. they produce more words per minute in conversation, and ask more questions than children who have received later intervention. These aspects could be investigated further, looking more specifically at the occurrences and types of vocabulary used and questions produced by the children, as well as incorporating and implementing more stringently drawn linguistic definitions (during coding) for these syntactic elements of language.

From the regression analyses in Table IVa, the length of time since referral was found to be the most important predictor for WDPM and PQ. We suggest that this indicates that it is not just the length of time since the child's hearing loss was found that is important, but also the time at which it was found. As mentioned above, meaningful and accurate analysis of factors such as 'time since referral' and 'time since fitting' become difficult when one considers that children who were referred/fitted late, for whatever reasons, may not have had aids for as long as others who may have been referred at the same time but fitted sooner. Reasons for the discrepancy between age at referral and age at hearing-aid fitting are various. There is no doubt that the Children's Hearing Assessment Centre in Nottingham aims to ensure an efficient service whereby the hearing-impaired child receives amplification, if appropriate, as early as possible after referral. Difficulties such as confirming diagnoses in younger infants, surgical intervention, lack of attendance on the part of the family at review clinics, non-acceptance of diagnosis by the family, or inability of the child to tolerate aids may constitute some of the causes.

Similarly, in addressing the question of early intervention, for a variety of reasons, only three subjects in this study were found to have been fitted with hearing-aids before 12 months of age. Two of these had profound hearing impairments and were excluded from the analyses due to insufficient verbal interaction for scoring purposes. At present, the proportion of hearing-impaired children, without multiple handicaps, detected within the first year of life is still small. A complexity in the composition of subject samples, additional to the difficulty of finding enough subjects receiving 'early' intervention, is a possible confounding variable. Additionally, many of the children referred 'late' for investigation of hearing impairment may have been referred because of notably poor development of spoken language, even though this may not have been explicitly recorded as a reason for referral. A selection bias on the dependent rather than the independent variable might then enter. This complexity is expected to change as more of those children suffering solely from mild/moderate/severe hearing impairments come to be detected 'early' (within one year) as a result of improved neonatal screening procedures. Therefore the possible benefits of fitting these children with hearing aids before they have reached 12 months of age need specifically to be evaluated. Studies of this nature are still few in number and in subsequent studies we hope to be able to locate a sufficient number of children with mild to severe hearing impairments to achieve this.

Regarding MLU, an age boundary of 4 years is often stipulated by investigators (Brown, 1973; Miller and Chapman, 1981; Wells, 1985) as the limit past which this measure reaches an asymptote and becomes unreliable. Despite being a less reliable indicator of syntactic ability for the older children in this study, we would nevertheless expect MLU scores for these children to fall around the peak of the asymptotic mean at 48 months. Many of the MLU scores, in comparison to Wells' template, were well below the mean in the data obtained for our older children and provides perhaps the most useful single indicator of the delay in language performance reported informally and in comparative studies of language development/emergence in hearing *v.* hearing-impaired children (White and White, 1987; Stokes and Bamford, 1990). Socio-economic grouping was found to be an important predictor of MLU score, but this relationship has to be viewed cautiously. Although this would suggest that the role of the family and home environment may account for a proportion of the variance, SEG itself remains difficult to measure definitively and other investigators have highlighted the difficulties in drawing conclusions from observed relationships between SEG and language performance (e.g. Wells, 1985). SEG influences are more accurately represented by a compound value derived from the consideration of many different factors (e.g. parental occupation, parental education/IQ, size of family, etc.), whereas our measure of SEG was based on one value – the occupation of the head of the household.

Our results relate expressive language in hearing-impaired children, not to the severity of their hearing impairments, but to age of intervention. However a number of further factors may have contributed to the children's outcome scores on language. For instance, even though rehabilitation in Nottingham aims to give a uniformly high standard of service, the subjects differed in the amount of exposure they had had to educational programmes, peripatetic teachers of the deaf, speech therapy etc., some having received none at the time of interview and others having received some form of regular supplementary help. Intervention variables may exert some influence on the children's language abilities and thus may need to be taken specifically into account in a global fashion, rather than statistically 'controlled' as in this study. Other studies of the effects of age of intervention have recognized that this incorporates a variety of 'several related events' (Geffner, 1987).

Here, we concentrated on four events – the age of detection, age of referral, age of first appointment and age of hearing-aid fitting. In addition, White and White (1987) in their study looking at age of intervention in relation to language comprehension and production (described earlier) identified 'age of onset of training of residual hearing', 'age of utilization of hearing aids', 'age of involvement of family' and 'age of entry into a programme' as factors combining to epitomize the 'compound concept' of age of intervention. Any future study addressing the question of age of intervention on the language ability of these children should take these stages into consideration as possibly separable contributory factors.

Individual differences constitute another factor influencing observed differences in performance. Individual IQ plays an important role in language performance and development (Levitt, 1987).

Finally, during this study, no record of operational hearing threshold level (with aids worn) at the time of interview was ascertained. It is hoped that the use of an Automated Toy Discrimination Test (Ousey *et al.*, 1990) for measuring hearing thresholds for speech sounds will be available in our future studies.

Conclusions

This study demonstrates that the observational language procedures and analyses employed reflect expressive spoken language in a heterogeneous group of hearing-impaired children in a way sufficiently precise to obtain expected results. The results found here suggest that even children with milder hearing losses may suffer detrimental effects in their development of spoken language if intervention is long delayed. This has been postulated by some of the few studies that have investigated the effects of milder, and fluctuating conductive (i.e. otitis media with effusion) losses on speech and language development (Klein & Rapin, 1988; Menyuk, 1986). More detailed and longitudinal investigations are needed on the spoken language abilities of children with mild-to-severe hearing impairments (both sensorineural and conductive), in comparison to normally hearing children of similar age, IQ and background, and in relation to age of intervention.

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Appendix

Language measures

There are several different approaches to the study of spoken language in children that can be utilized. A number of language schedules exist (e.g. Early Language Milestone Scale (ELM) – Coplan, 1983; LARSP – Crystal, 1976; Bristol Language Development Scales (BLADES) – Gutfreund, 1989) which are designed to monitor the patterns of normal language development. Others (Language Development Survey (LDS) – Rescorla, 1989) have been designed for use with specifically language-impaired children. Such scales aim to provide a means of determining child language development level, and to reveal deficits in the course of 'normal' language acquisition where they may have arisen. Many of the schedules consist of detailed phonetic evaluation within a pre-defined framework, and most are designed for administration on specific age groups; for example REEL (Receptive–Expressive Emergent Language Test, 1971) and ELM scale (Coplan, 1983) are for use with children 36 months of age or younger.

The heterogeneity of populations of hearing-impaired children renders the utility of many of these established and more detailed measures of spoken language ability difficult, few having been modified for use with such groups. In addition, the lack of suitable numbers of hearing-impaired children of the same age with similar rehabilitation regimes meant that the sample of children in this study incorporated a wider age range than any one test could suitably cover. Taking these factors into consideration, most existing schedules for determining children's spoken/expressive language ability were therefore deemed inappropriate for use on our population of children, and an open-ended group of measures of spoken language were adopted. If these showed the expected significant association with the children's chronological age, then the effects of hearing loss and age of intervention for their impairments could be investigated, and more precise measures considered at a later stage.

The 'language metrics' chosen consisted of: (i) basic measures of syntactic complexity – MLU and VOC; (ii) measures pertaining to the child's rate of interaction – TUA and WPM/WDPM; and (iii) measures related to communication clarity and discourse – PQ and PNV.

Whilst such measures may not throw light upon detailed linguistic structures or on acquisition processes, they have the merits of wide comprehensibility and give a robust summary of much of the obtained data. MLU, for example, is relatively easy to implement and is a good indicator of syntactic development in young pre-school children (Brown, 1973). Several studies have highlighted its value when used carefully on selected populations (Scarborough *et al.*, 1986). Miller and Chapman (1981), for instance, found that, for a defined middle-class population of children aged 17 to 59 months, MLU could be well predicted from age (cut-off age between 42 and 48 months) and was a good aid for a preliminary evaluation of linguistic competence. Despite its sensitivity to changes in setting and environment, MLU was deemed to be a suitable measure of grammatical development for the children in this study.

Once children have produced their first word, usually somewhere between 9 and 18 months, vocabulary is found to expand progressively. Several studies have incorporated the expansion of children's vocabulary (or rate of acquisition of words) as a rudimentary measure of their expressive language (Wellen, 1985; Geffner, 1987). For instance, Nelson (1981) and Thatcher (1976) looked at the period over which a group of infants' vocabulary expanded from 10 to 50 words in order to monitor language development. Gregory and Mogford (1981) similarly utilized vocabulary growth to measure early language development in six hearing-impaired children. They looked at the ages at which these children acquired vocabulary sizes of one, ten, fifty and a hundred words, finding that the ages of emergence for each of these stages was significantly delayed when compared to results for hearing children.

The cross-sectional nature of the study presented here did not allow for the monitoring of the emergence of specific milestones in vocabulary growth. However, vocabulary size was included as one fundamental measure of spoken language ability. An estimate of vocabulary size was derived from a count of the total number of different word roots employed by the child during a given period of the recorded episode.

For the purposes of this study, WPM and TUA were chosen as indicators of the rate of communication exchange and the quantity of language used, while PQ and PNV were taken to be representative of the child's attempts to promote communication and discourse with his/her interlocutor.