Outcomes for Young Children with Hearing Loss in an Auditory-Verbal Therapy Program

Dimity Ann Dornan

A thesis submitted for the degree of Doctor of Philosophy
at the University of Queensland
in November 2010

School of Health and Rehabilitation Sciences
Declaration By Author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution made by others to jointly authored works and I have included this in my thesis.

I have clearly stated the contribution made by others as a whole, including statistical assistance, data analysis, professional editorial advice, and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my research higher degree candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or tertiary institution.

I acknowledge that an electronic copy of my thesis must be lodged with the University Library, and, subject to the General Award Rules of the University of Queensland, immediately made available for research and study in accordance with the Copyright Act 1968.

I acknowledge that copyright of all material contained in my thesis resides with the copyright holder(s) of that material.

Dimity Ann Dornan
Statement of Contribution to Jointly Authored Works Contained in the Thesis


   *Dornan was primarily responsible for concept development, data collection, analysis, reviewing drafts and editing. Hickson contributed to concept development, analysis, reviewing drafts and editing. Other authors contributed to reviewing drafts and editing.*


   *Dornan was responsible for reviewing the literature and writing the paper. Hickson contributed to reviewing drafts and editing, and other authors were involved in this process.*


   *Dornan was primarily responsible for concept development, data collection, analysis, reviewing drafts and editing. Hickson contributed to concept development, analysis, reviewing drafts and editing. Other authors contributed to reviewing drafts and editing.*

Dornan was primarily responsible for concept development, data collection, analysis, reviewing drafts and editing. Hickson contributed to concept development, analysis, reviewing drafts and editing. Other authors contributed to reviewing drafts and editing, and Constantinescu also contributed to data analysis.
Statement of Contributions by Others to the Thesis as a Whole

The PhD candidate was primarily responsible for the concept and design of the study, gaining ethical approval, participant recruitment, data collection, analysis and interpretation, and manuscript preparation. However, significant contributions to the thesis as a whole have been made by the following people:

Professor Louise Hickson had substantial input into the concept and design of each study, the analysis and interpretation of data, and critical appraisal of written work.

Professor Bruce Murdoch and Assistant Professor Todd Houston had input into the concept and design of the study, reviewing of drafts and editing.

Dr Ross Darnell and Dr Gabriella Constantinescu had substantial input into the statistical analysis and interpretation of data.

To the best of my knowledge and belief, no person who has offered contributions consistent with the above has been excluded as an author. Persons who have contributed to the work but not at a level that constitutes authorship have been acknowledged in the text.

Dimity A. Dornan  
PhD Candidate

Louise Hickson  
Principal Advisor

Bruce Murdoch  
Associate Advisor

Todd Houston  
Associate Advisor
List of Parts of the Thesis Submitted to Qualify for the Award of Another Degree

Chapter 3 was originally completed as part of an MPhil, University of Queensland, 2/7/07. However, the candidate subsequently changed enrollment to a PhD and withdrew from the MPhil.
Published Works by the Author
Incorporated into the Thesis


*The entire paper plus additional references published since 2008 incorporated as Chapter 2.*


*The entire paper plus additional references published since 2007 incorporated as Chapter 3.*


*The entire paper incorporated as Chapter 4.*


*The entire paper incorporated as Chapter 6.*

The above articles have been inserted into the thesis as accepted for publication by the journal. Tables and figures have been imbedded in the text; and references are presented at the end of the relevant chapters. Figures and table numbers, as well as headings and page numbers have been adjusted to maintain consistency throughout the thesis.
Additional Publications by the Author Relevant to Thesis But Not Forming Part of It


List of Presentations by the Author Relevant to the Thesis

(The presenting author is shown in bold print)

The following presentations about the research presented in this thesis have been delivered at national and international conferences during the period of candidature:


Acknowledgements

I would like to thank all those who have inspired me to complete my Doctoral studies, and supported me while I did so.

Firstly, I would like to thank my special supervisor, Professor Louise Hickson, who has so wisely guided and encouraged me with expertise and caring. I would also like to give my sincere appreciation to Professor Bruce Murdoch for his interest and support, and to Assistant Professor Todd Houston for his invaluable input.

My very special thanks must go to the Hear and Say children themselves and their parents who committed to the four years of this longitudinal study. This has indeed been a labour of love! Also, the children with typical hearing and their parents who participated have given an invaluable donation of time and effort to the Hear and Say Centre, and I am truly grateful.

This research study would have been impossible without the support and understanding of the Board of Directors and staff of the Hear and Say Centre. I would like to thank them all for sharing my vision regarding the importance of producing outcomes data for children of the future. Many staff members and volunteers have faithfully contributed in so many ways in the gathering and electronic storing of data, and in ensuring that assessment schedules were kept, no mean feat in a centre caring for over four hundred children. In addition, the work of Dr Ross Darnell of the School of Health and Rehabilitation Sciences, University of Queensland, and Dr Gabriella Constantinescu of the Hear and Say Centre in the statistical analysis of the study has been a necessary contribution of great value. Many professionals have offered advice, including Distinguished Professor Carol Flexer, Dr Anu Sharma, and Dr Geoffrey Foster.

Financial support for this study has been provided by the Hear and Say Centre; School of Health and Rehabilitation Sciences, University of Queensland, Brisbane, Australia; Queensland Council of Allied Health Professionals; and the Commonwealth of Australia, through the Cooperative Research Centre for Cochlear Implant and Hearing Aid Innovation (CRC HEAR, Australia). The author also wishes to acknowledge the support of Ellen McKeering, Dr Melody Harrison and Catherine Bow. Special thanks must go to Carol Jackson, Jane Brady, Samantha Hauff and Renee O’Ryan who have helped in manuscript preparation.
Lastly I would like to acknowledge my very understanding family and friends who have supported me over the 8 years I have been working towards this PhD. Especially I would like to thank my two children, Melissa Bruijn and Rod Dornan and their families, and my three grandchildren who have done without me on so many occasions. Of all those who have helped me, my husband Peter has made by far the largest contribution, having stood behind me with practical and emotional support every single day.

Finally, I would like to acknowledge my constant inspiration and source of passion, the “Children of Tomorrow”, yet unborn, who will be diagnosed with hearing loss in future years, and whose parents and professionals so badly need evidence-based practice to guide them on the path to helping their child reach their full potential.
Abstract

Hearing loss is the most common disability in newborns, having a significant impact on the child and his/her family. During the last 20 years, it has become possible to reduce this impact through two major advances: the increasing use of newborn hearing screening, and the development of modern hearing technology. Furthermore, emerging neuroscience research is substantiating the rationale for the combination of early diagnosis and fitting of hearing technology with early auditory brain stimulation, resulting in maturation of the auditory neural system, a precondition for development of listening and spoken language. New evidence is needed for the effectiveness of education approaches in delivering auditory brain stimulation and developing listening and spoken language.

These advances have driven the development of one education approach, Auditory-Verbal Therapy (AVT), which is described in relation to other education approaches in the Introduction of this thesis (Chapter 1). A review of evidence related to AVT is included in Chapter 2. This thesis then reports the outcomes of an AVT program for a group of children with hearing loss (AVT group) compared with those for a control group of children with typical hearing (TH group) in a longitudinal study over 50 months (Chapters 3 to 6).

The AVT group were educated according to the principles of AVT in which children with hearing loss and their parents are educated simultaneously in order to guide and coach parents to provide their child with access to spoken language through audition. The AVT program in this study endorsed early identification and diagnosis, early audiological intervention, and parent-based education focused on developing the child’s auditory brain pathways, listening and spoken language, with the ultimate goal of education in the mainstream. However, there is very little available evidence for the efficacy of AVT, or for any other education approach. Moreover, there is a lack of large-scale, robust studies on the outcomes of AVT for children with hearing loss.

The research study had a matched group repeated measures design and was developed to measure outcomes for a group of 29 children aged 2 to 6 years educated with AVT. At the commencement of the study, the AVT and TH groups of children were matched for gender, language age, receptive vocabulary and socioeconomic level. The children were tested at various time points, including the pretest (baseline), followed by posttests at 9 months (Chapter 3), at 21 months (Chapter 4), at 38 months (Chapter 5), and at 50 months (Chapter 6) from the start of the
A battery of speech perception, language and speech tests was devised to measure the speech perception, language and speech outcomes for the two groups. The test battery included speech perception tests for the AVT group for live and recorded voice delivered in successive stages (pretest-21 months, 21-38 months, and 38-50 months from the start of the study). A battery of speech and language assessments was also administered at the start of the study (pretest) and at the 9, 21, 38 and 50 months posttests to both groups of children. Reading, mathematics and self-esteem assessments were added at the 38 and 50 months posttests for both the AVT and TH groups.

Results showed that the speech perception skills for the AVT group improved significantly ($p = <0.05$) from the pretest to the 38 months posttest for both the live and recorded voice measures (Chapters 4 and 5). From the 38 months posttest to the 50 months posttest, speech perception scores for live voice remained high and stable, and recorded voice scores were moderately high, indicating a good level of speech perception skills (Chapter 6).

Overall, the total language, receptive vocabulary and speech measures showed that significant progress was made for both the AVT and TH groups for the children who continued ($n = 19$) over the course of the study (pretest to 50 months). There were no significant differences in the rates of progress between the two groups for total language and speech skills from the pretest to the 50 months posttest. However, receptive vocabulary scores for the TH group showed significantly better rates of progress than the AVT group from the pretest to the 21 months and the 38 months posttests, however the AVT group mean scores were within the typical range for their mean chronological age. Furthermore, there was no significant difference between the AVT and TH groups for the rate of progress for receptive vocabulary from the pretest to the 50 months posttest. Mean total language score for the AVT group was only 2 months lower than those for the TH group at the 50 months posttest (Chapter 6).

Preliminary results for reading and mathematics were based on the scores for a small number of pairs of AVT and TH group children ($n = 7$) who had reached school age, and had scores both for the 38 months and 50 months posttests. The numbers in each group were considered too small for statistical comparison. However the scores for the AVT and TH groups were comparable at both posttests (Chapters 5 and 6). Parents rated their child’s self-esteem as high, with no significant differences between the AVT and TH groups at both the 38 months and 50 months posttests (Chapters 5 and 6).
Chapter 7 provides a discussion, clinical implications, limitations of the study and conclusions. Overall, these findings have demonstrated that the AVT group progressed at essentially the same rate for total language, receptive vocabulary and speech skills as the TH group. This thesis has outlined a research model for measuring the outcomes of education intervention and other treatments for children with hearing loss. It contributes evidence towards a benchmark of 12 months of progress in 12 months of time for the language progress of children with hearing loss. The studies in this thesis form part of the first longitudinal evaluations of outcomes of an AVT program that have included a control group with typical hearing.

This study has highlighted that children with hearing loss who are identified around 22 months of age, fitted with modern hearing technology and educated using AVT have the potential to progress in the development of total language, receptive vocabulary, and speech skills at the same rate as children with typical hearing of the same initial language age. These children also have potential for being educated in the mainstream with comparable reading and mathematics, and the same level of self esteem as typically hearing children.

Future research needs include the investigation of outcomes for larger numbers of children with hearing loss using AVT, both from similar and different populations to the group studied here. The same research model could be used for comparing outcomes for children in alternative education approaches. Reading and mathematics outcomes for children with hearing loss also need to be studied for an extended period. In addition, there is a critical need to study outcomes of an AVT program for babies, particularly those diagnosed through newborn hearing screening.

In summary, AVT has proved to be an effective education option for this particular group of children with hearing loss.

Key Words:
hearing loss, deaf, hearing impaired, children, language, speech, reading, mathematics, self-esteem, Auditory-Verbal Therapy
Note

The international terminology for the type of education approach for children with hearing loss researched in this thesis, Auditory-Verbal Therapy (AVT), was officially standardised by the Alexander Graham Bell Academy for Listening and Spoken Language in November 2007. The official terminology is currently “Auditory-Verbal Therapy”. In Chapter 3 of this Thesis, the terms “Auditory-Verbal approach” or “Auditory-Verbal practice” are used to refer to AVT, as the article that forms this chapter was published using earlier terminology (Dornan, Hickson, Murdoch, & Houston, 2007). All other occurrences of the term in this thesis have been corrected to be in accordance with the new terminology. For a full discussion of this topic, see Chapter 1, Section 1.6, p.10.

The term “Auditory-Verbal Education” was not included in the description of education options in Chapter 3 because this paper was accepted before the use of this terminology was introduced. In this thesis, the term “typical hearing” (TH) has been used to describe children with normal hearing because of editorial preferences of the journal in which the majority of the research papers were published. To maintain consistency, this term “typical hearing” has been used throughout the thesis, except where it occurs as part of the title of a published paper.

The references for the published chapters (Chapters 2, 3, 4, and 6) are included at the end of each thesis chapter, and those for the unpublished chapters (Chapters 1, 5, and 7) are at the end of Chapter 7.

As the PhD candidate was Managing Director and Founder of the Hear and Say Centre during the study, there could be some perceived conflict of interest. However, except for some children in the initial round of testing whom the candidate tested personally, the majority of tests were performed by other appropriately qualified professionals. These were either the staff of the centre, or outside employed testers, and were sometimes the child’s own therapist, but mostly they were a different therapist or outside tester. The data analysis was conducted by the candidate in collaboration with a University of Queensland statistician and a staff member of Hear and Say. The co-authors/supervisors are all from universities not affiliated with the Hear and Say Centre.
Australian and New Zealand Standard Research Classifications (ANZSRC)

929201 Allied Health Therapies 100%
# Table of Contents

Declaration By Author.................................................................................................................. iii  
Statement of Contribution to Jointly Authored Works Contained in the Thesis............................... v  
Statement of Contributions by Others to the Thesis as a Whole ................................................ vii  
List of Parts of the Thesis Submitted to Qualify for the Award of Another Degree ......................... ix  
Published Works by the Author Incorporated into the Thesis ......................................................... xi  
Additional Publications by the Author Relevant to Thesis But Not Forming Part of It ......................... xiii  
List of Presentations by the Author Relevant to the Thesis ............................................................. xv  
Acknowledgements....................................................................................................................... xvii  
Abstract.......................................................................................................................................... xvii  
Note.................................................................................................................................................. xxiii  
Australian and New Zealand Standard Research Classifications (ANZSRC) ...................................... xxv  
Table of Contents........................................................................................................................... xxvii  
List of Tables...................................................................................................................................... xxxi  
List of Figures .................................................................................................................................... xxxiii  
List of Abbreviations Used in the Thesis........................................................................................... xxxv

## CHAPTER ONE..........................................................................................................................1

1.1 BACKGROUND ....................................................................................................................... 1  
1.2 IMPACT OF HEARING LOSS IN CHILDREN........................................................................ 2  
1.3 EARLY DETECTION, DIAGNOSIS AND INTERVENTION................................................... 4  
1.4 AUDIOLOGICAL INTERVENTION ......................................................................................... 5  
1.4.1 Hearing aids ....................................................................................................................... 5  
1.4.2 Cochlear implants ............................................................................................................... 6  
1.5 EDUCATIONAL INTERVENTION ......................................................................................... 7  
1.6 PRINCIPLES OF AUDITORY-VERBAL THERAPY (AVT) .................................................. 10  
1.7 AIMS OF THE THESIS AND OVERVIEW............................................................................. 11

## CHAPTER TWO........................................................................................................................15

2.1 INTRODUCTION....................................................................................................................... 16  
2.2 BACKGROUND ....................................................................................................................... 16  
2.3 AUDITORY-VERBAL THERAPY (AVT) ............................................................................... 17  
2.4 EVIDENCE-BASED PRACTICE ............................................................................................. 20
CHAPTER FIVE .................................................................................................................. 107
5.1 INTRODUCTION ......................................................................................................... 108
5.2 METHOD .................................................................................................................... 109
  5.2.1 Participants ........................................................................................................... 109
  5.2.2 Materials ............................................................................................................... 110
  5.2.3 Procedure ............................................................................................................ 114
5.3 RESULTS .................................................................................................................... 114
  5.3.1 Speech Perception ............................................................................................... 114
  5.3.2 Speech and Language ......................................................................................... 118
  5.3.3 Reading and Mathematics .................................................................................. 120
  5.3.4 Self-esteem .......................................................................................................... 120
5.4 DISCUSSION ............................................................................................................... 121
  5.4.1 Speech Perception ............................................................................................... 121
  5.4.2 Speech and Language ......................................................................................... 122
  5.4.3 Reading and Mathematics .................................................................................. 124
  5.4.4 Self-esteem .......................................................................................................... 125
  5.4.5 Limitations ........................................................................................................... 125
5.5 CONCLUSION .............................................................................................................. 126

CHAPTER SIX .................................................................................................................... 127
6.1 INTRODUCTION ......................................................................................................... 128
6.2 METHOD .................................................................................................................... 131
  6.2.1 Participants ........................................................................................................... 131
  6.2.2 Materials ............................................................................................................... 136
6.3 PROCEDURE ............................................................................................................... 139
6.4 RESULTS .................................................................................................................... 140
  6.4.1 Speech and Language ......................................................................................... 140
  6.4.2 Receptive Vocabulary ......................................................................................... 142
  6.4.3 Speech ................................................................................................................ 142
  6.4.4 Reading and Mathematics .................................................................................. 142
  6.4.5 Self-esteem .......................................................................................................... 143
6.5 DISCUSSION ............................................................................................................... 145
6.6 SUMMARY .................................................................................................................. 149
6.7 REFERENCES .............................................................................................................. 151

CHAPTER SEVEN ............................................................................................................ 159

7.1 SUMMARY .................................................................................................................. 159
7.2 IMPLICATIONS FOR IDENTIFICATION, DIAGNOSIS AND INTERVENTION .......... 165
7.3 LIMITATIONS OF STUDY .......................................................................................... 166
7.4 FUTURE DIRECTIONS ................................................................................................. 167
7.5 CONCLUSIONS .......................................................................................................... 167
7.6 GENERAL REFERENCES ......................................................................................... 169

List of appendices .............................................................................................................. 183
List of Tables

Table 1.1 Domains tested and comparisons reported at various testing points in the study ..........14
Table 3.1 Characteristics of AVT group at 9 months posttest .......................................................54
Table 3.2 Order of presentation for standardised assessments..........................................................58
Table 3.3 Mean age equivalents (in years), standard deviations, t and p values for auditory comprehension, oral expression, total language, receptive vocabulary, and speech for the 29 children in the AVT and TH groups at pretest and at 9 months posttest ........................................60
Table 3.4 Summary of age equivalent gains (in months) for both groups over nine-month test period .................................................................61
Table 4.1 Characteristics of AVT group and TH group at 21 months posttest ..................................75
Table 4.2 Occupation category of head of the household for AVT group and TH group ............ 77
Table 4.3 Battery of assessments ..................................................................................................79
Table 4.4 AVT group speech perception results at pretest and posttest (expressed as percentage correct) for PLOTT Phoneme Detection, Manchester Junior Words, CNC Words, and BKB Sentences .................................................................87
Table 4.5 Mean age equivalents, standard deviations, t and p values, for total language, receptive vocabulary and speech for the 25 children in the AVT and TH groups at pretest and 21 months posttest .................................................................................................90
Table 4.6 Summary of CASALA scores (percentage) and statistical tests of change over time for AVT group consonants attempted and consonants correctly produced .................................92
Table 5.1 Characteristics of AVT group and TH group at 38 months posttest ..........................110
Table 5.2 Battery of reading, mathematics and self-esteem assessments added at 38 months posttest ..............................................................................................................................112
Table 5.3 Speech perception results for AVT group at 21 months posttest and 38 months posttest (expressed as percentage correct), z and p values for PLOTT Phoneme Detection, CNC Words, and BKB Sentences .............................................................................................................116
Table 5.4 Mean age equivalent (in years), standard deviations (in parentheses), t and p values for total language, receptive vocabulary, and speech for the AVT and TH groups at pretest and at 38 months posttest ........................................................................................................119
Table 5.5 Summary of mean percentile ranks for reading and mathematics for the 13 pairs of children in the AVT group and TH group at 38 months posttest and results of statistical analysis of differences between groups using Mann-Whitney Tests ........................................120
Table 5.6 Self-esteem scores for parent responses for AVT group and TH group for 14 pairs of children using Primary Insight and statistical analysis for difference between groups using Mann-Whitney Tests ........................................................... 121

Table 6.1 Characteristics of AVT group and TH group at 50 months posttest......................... 132

Table 6.2 Battery of assessments .......................................................................................... 136

Table 6.3 Mean age equivalents (in years), standard deviations (in parentheses), z and p values for total language, receptive vocabulary and speech for the 19 children in the AVT and TH groups at pretest and at 50 months posttest ................................................................. 141

Table 6.4 Percentile ranks for reading and mathematics for the 7 pairs of children in the AVT group and TH group at 38 and at 50 Months Posttest................................................................. 143

Table 6.5 Raw scores for self-esteem for AVT group and TH group for Primary Insight at 38 and 50 months posttests .................................................................................................. 144
List of Figures

Figure 1.1 Diagrammatic representation of the communication options showing how each relates broadly to spoken language or visual language. Adapted from Gravel and O’Gara (2003).................8
AG Bell = Alexander Graham Bell Association for Deaf and Hard of Hearing
AG Bell Academy = Alexander Graham Bell Academy for Listening and Spoken Language
AVEd = Auditory-Verbal Education
AVT = Auditory-Verbal Therapy
BKB = Bench-Kowal-Bamford sentence test
CAEP = Cortical Auditory Evoked Potential
CELF = Clinical Evaluation of Language Fundamentals
Cert. AVT® = Certified Auditory-Verbal Therapist
Cert. AVEd ® = Certified Auditory-Verbal Educator
CI = cochlear implant
CNC = Consonant-Nucleus-Consonant
GFTA = Goldman Fristoe Test of Articulation
HA = hearing aid
IEP = Individual Education Program
LSLS = Listening and Spoken Language Specialist
NAL = National Acoustic Laboratory (Australia)
OC = Oral Communication
PATMaths = Progressive Achievement Tests in Mathematics
PBK = Phonetically Balanced Kindergarten Words Test
PLS = Preschool Language Scale
PPVT = Peabody Picture Vocabulary Test
PTA = Pure Tone Average
RPT = Reading Progress Tests
TC = Total Communication
TH = Typical hearing
CHAPTER ONE

An Introduction to Hearing Loss in Children

1.1 BACKGROUND

This thesis investigated the outcomes for a group of children with hearing loss in an Auditory-Verbal Therapy (AVT) program. AVT is an education approach that is increasingly employed worldwide by the parents and professionals of children with hearing loss, particularly with young children (Rhoades, 2006). It consists of the application of techniques, strategies, conditions and procedures that promote the acquisition of spoken language through listening (Estabrooks, 1994; 2005). AVT focuses on developing listening and spoken language through audition, using parents as the child’s natural language teachers, with the aim of full inclusion in the mainstream (Pollack, 1970; Alexander Graham Bell Academy for Listening and Spoken Language, 2007).

Advancements in technology have forged a new era in the diagnosis and treatment of paediatric hearing loss, which have created unprecedented potential for listening and spoken language for children with hearing loss (Nicholas & Geers, 2006; Yoshinaga-Itano, 2004). Significant technological developments have included newborn hearing screening, new objective diagnostic tests, digital hearing aids, cochlear implants and auditory signal processing. Along with these advancements, a confluence of research from many other sciences is occurring, creating previously unimagined options for the treatment of paediatric hearing loss.

Before the advent of new hearing technology, such as cochlear implants, congenital hearing loss in a child prevented sound stimulation from reaching auditory brain centres, resulting in lack of auditory brain development, particularly if not detected early (Gilley, Sharma, & Dorman, 2008). Auditory stimulation influences the organization and maturation of auditory brain pathways, allowing a child to make meaning out of what they hear (Boothroyd, 1997; Chermack, Bellis, & Musiek, 2007). Today, with newborn hearing screening and new hearing devices, it is possible to provide early auditory brain access, and to stimulate the brain with abundant, meaningful acoustic
experiences within the first few years of life, the period of maximum neuroplasticity (Sharma, Dorman, & Spahr, 2002; Sharma, Dorman, & Kral, 2005). This stimulation results in the development and maturation of the central auditory system, a precondition for the normal development of speech and language skills in children (Boothroyd, 1997; Cole & Flexer, 2006; Dornan, 2009; Engineer et al., 2004; Kral, Hartmann, Tillein, Heid, & Klinke, 2002; Vouloumanos & Werker, 2004). Consequently, it is essential for early and ongoing auditory and educational intervention to access and develop the auditory brain centres (Robbins, Koch, Osberger, Zimmerman-Philips, & Kishon-Rabin, 2004).

Because of this increased potential for auditory brain development, new evidence is needed for the effectiveness of different educational options used for developing auditory brain centres and providing optimal outcomes for children. Currently there is very little high level outcomes evidence for the effectiveness of any particular education approach (Sussman, Duncan, Estabrooks, Hulme, Moog, & McConkey Robbins, 2004), nor is there a widely accepted model for evaluating effectiveness (Eriks-Brophy, 2004).

1.2 IMPACT OF HEARING LOSS IN CHILDREN

The incidence of permanent hearing loss in children ranges from 1.2 to 6 per 1,000 live births worldwide, the incidence rising ten-fold in children who receive intensive care at birth (Cunningham & Cox, 2003; Fortnum, Summerfield, Marshall, Davis & Bamford, 2001; Kemper & Downs, 2000; Mason & Herrmann, 1998). Greater incidences have been found in developing countries (Olusanya, Ruben, & Parving, 2006; UNICEF, 2006). In Australia, congenital hearing loss of greater than 35 dB in both ears occurs in 1.3 per 1,000 live births while acquired hearing loss occurs in 3.2 per 1,000 infants born (Medical Services Advisory Committee, 2007). There is growing evidence in the literature to support the serious impact of hearing loss on the child, the family and the community.

Untreated paediatric hearing loss has a significant impact on a child’s auditory brain maturation, as evidenced by delayed latency of the P1 cortical auditory evoked potential (CAEP), which is a specific response to sound generated by auditory thalamic and cortical sources and captured through electrodes placed on the child’s scalp (Sharma, Dorman, & Kral, 2005; Ponton, Don, Eggermont, Waring, Kwong & Masuda, 1996; Ponton, Moore & Eggermont, 1999; Sharma, Dorman, & Spahr, 2002a,b). This neurological impact of hearing loss on the CAEP can be shown even in infants younger than 6 months of age (Golding, Pearce, Seymour, Cooper, Ching, & Dillon,
2007). The impact of significant hearing loss on the central nervous system has also been shown in deaf cats in which substantial functional deficits have been found in the primary auditory cortex (Kral, Hartmann, Tillein, Heid, & Klinke, 2000; Klinke, Hartmann, Heid, Tillein, & Kral, 2001).

The impact on the auditory brain activity of a child with hearing loss who is deprived of sound for a long period is more significant than the impact for a child deprived for a short period. Sharma, Dorman, and Kral (2005) have found that for those children with long term hearing loss, the outcome is cross modal re-organization of the brain (reassignment of auditory brain cells to other functions such as vision) and this limits the neuroplastic adaptation of the cortex to auditory input (Lee et al., 2001; Neville & Bavelier, 2002; Nishimura et al., 2000; Petitto et al., 2000; Roder, Stock, Bien, Neville, & Rosler, 2002). Hence, to circumvent the negative impact of the reorganisation of auditory brain pathways, which causes reduced potential for listening, timing of intervention is an important consideration. The potential impact of deafness on the neural system of the child is exacerbated by late diagnosis and treatment. Research on the impact of hearing loss has shown that, if appropriate early auditory exposure and auditory brain development are not experienced, the result is linguistic and communication deficits which may be lifelong (Molfese, 2000; Tsao, Lieu, & Kuhl, 2004; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998).

Researchers have found that paediatric hearing loss adversely affects development of auditory skills (Sininger, 1999), and speech and language (Blamey, Sarant et al., 2001; Geers & Moog, 1994). A bilateral severe or profound loss will cause significant effects on speech and language development, particularly if not detected early (Andrews & Mason, 1991; Erenberg, Lemons, Sia, Trunkel, & Ziring, 1999; Geers & Moog, 1989; Thompson, McPhillips, Davis, Lieu, Homer, & Helfand, 2001). Even a unilateral, mild or moderate hearing loss may impact on speech and language development (Moeller, 2000; Tharpe & Bess, 1991; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998).

Hearing loss also negatively affects the development of reading abilities because phonological processing, one of the fundamental prerequisites for reading takes place in the auditory areas of the brain (Werker & Tees, 2005). Neural imaging has shown a strong relationship between phonological processing and reading skills (Gabrielli, 2009; Strickland & Shanahan, 2004). Related to this, childhood hearing loss can also restrict writing ability and overall educational achievements (Nathan, Goulandris, & Snowling, 2004; Wray, Hazlett, & Flexer, 1988). Traxler (2000) reported that 4,804 children with severe to profound hearing loss, on average, completed the twelfth grade with a third to fourth grade reading level, the language levels of a nine to ten-year old child with
normal hearing, also having severely compromised mathematics ability. Behaviour is also adversely affected in some individuals (Prizant & Meyer, 1993). In addition, an adult with significant congenital hearing loss may experience compromised long term career development and problems with mental health (Laurenzi & Monteiro, 1997), self-esteem (Batchava, 1993; Nicholas & Geers, 2003), and socio-emotional development (Watson, 1990).

Hearing loss in a child may also impact negatively on the child’s family (Young & Tattersall, 2007). The negative effects of a child’s hearing loss on the family are initially centred on the parent’s response to the diagnosis, and adapting to the needs of the child (Feher-Prout, 1996). The long-term impact on the family includes chronic parental grief and stress, emotional sensitivity, depression, feelings of disgrace and denial and the need to change their lives in order to meet the ongoing challenges (Anagnostou, Graham, & Crocker, 2007; Calderon & Greenberg, 1999; Feher-Prout, 1996; Hintermair, 2006; Kurtzer-White & Luterman, 2003; Kushalnagar et al., 2007; Lederberg & Golbach, 2002; Zaidman-Zait, 2007). The child’s family is also impacted with problems with the development of parent-child relationships because communication between the child and the family is compromised, particularly if the family has normal hearing (Blum, Fields, Scharfman, & Silber, 1994). These effects on the family can, in turn, have an impact on the social environment in which the child learns language and also the child’s cognitive and socio-emotional development (Hintermair, 2006; Koester & Meadow-Orlans, 1999; Zaidman-Zait & Most, 2005). Consequently, the diagnosis of hearing loss has significant pervasive effects on both the family and the child.

In summary, untreated hearing loss in a child has a significant impact on their auditory brain development that results in serious consequences for speech, language, literacy, academic achievements, and social/emotional development for the child’s life term. These chronic disabilities also impact significantly on the family and community (Olusanya, Ruben, & Parving, 2006).

1.3 EARLY DETECTION, DIAGNOSIS AND INTERVENTION

Early detection, diagnosis and intervention are critical for minimizing the potentially serious consequences of hearing loss in children (Cole & Flexer, 2007). Prior to the introduction of universal newborn hearing screening in Australia, the median age of detection of Australian children with the most severe hearing losses (>90dB) was between 12 and 18 months while the median age at detection of children with moderate hearing losses (40-60dB) was between 4 and 5 years (Wake, 2003).
Infants and children with mild to profound hearing loss who are identified in the first 6 months of life and provided with immediate and appropriate intervention have significantly better language development than later-identified infants and children, and have the potential to develop language skills within the normal range (Calderon & Naidu, 2000; Mayne, Yoshinaga-Itano, & Sedey, 1998; Mayne, Yoshinaga-Itano, Sedey, & Carey, 1998; Moeller, 2000; Pipp-Siegel, Sedey, VanLeeuwen, & Yoshinaga-Itano, 2003; Yoshinaga-Itano, 2004; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). These improved outcomes following early identification and intervention are also found for speech production (Apuzzo & Yoshinaga-Itano, 1995; Yoshinaga-Itano & Apuzzo, 1998a,b; Yoshinaga-Itano, Coulter, & Thompson, 2000). Other authors have shown that an early age of identification of hearing loss also has benefits for social and emotional development for children with hearing loss (Hintermair, 2006). Most importantly, it has been shown that early screening and identification alone do not lead to positive outcomes, and it is crucial that these are followed by immediate, early audiological and educational intervention (Yoshinaga-Itano, 2004). Although there is a need to extend these studies to different and more diverse populations, and to better describe educational intervention programs, the evidence for the potential for positive benefits of early identification, diagnosis and audiological and educational intervention is escalating.

1.4 AUDIOLOGICAL INTERVENTION

Audiological intervention for a child with hearing loss consists of diagnostic assessment to determine the nature and degree of hearing loss, followed by fitting of one or two hearing devices to allow the child’s brain access to auditory stimulation. Appropriate audiological management and amplification using modern technology are essential for positive outcomes for children with hearing loss (Arehart & Yoshinaga-Itano, 1999). The two most common types of hearing technology used currently are digital hearing aids and cochlear implants.

1.4.1 Hearing aids

A hearing aid consists of a microphone to convert sound into electricity, an earmould that transmits sound into the ear, an amplifier to increase the strength of the electrical signal, a miniature loudspeaker, a means of coupling the amplified sound into the ear canal and a battery (Dillon, 2001). A behind the ear aid (BTE) is the most appropriate hearing aid for children and bilaterally
fitted hearing aids are recommended for children with bilateral hearing loss (American Academy of Audiology, 2004). A digital hearing aid is a device that receives sound and digitizes it, or breaks sound waves up into small, discrete units prior to amplification. A digital hearing aid can be programmed to adjust to the acoustic environment millions of times each second. Digital technology also makes it possible for clinicians to create customized programs that address an individual's specific hearing difficulties. All children in the current research project wore digital hearing aids that were fitted by Australian Hearing, the national body that provides hearing aids for all Australian children with hearing loss under the age of 18 years.

1.4.2 Cochlear implants

A cochlear implant is a surgically inserted biomedical device designed to provide sound information to children and adults who experience severe to profound hearing loss. A cochlear implant consists of a microphone worn externally (which picks up sound signals from the environment), the external speech processor (hardware which is programmed with speech processing strategies to select and arrange the speech signal which is picked up by the microphone) and the surgically implanted electrode array (which bypasses damaged hearing cells in the cochlea) (Clark, 2003). Once implanted, the speech processor is linked to a computer and programmed for the individual child over several months in a process called “MAPping”. Many children wear a cochlear implant in one ear and a hearing aid on the contralateral side, or more recently, bilateral cochlear implants. Speech processing strategies are adapted to improve the perception of loudness by users, and to improve speech perception. The overall contribution of stimuli to simulated loudness is compared with an estimate of acoustic loudness for a normally hearing listener based on the input sound signal. A weighting is applied to the filter channels to emphasize those frequencies that are most important to speech perception for normal hearing listeners when selecting channels as a basis for stimulation. All children in the current project had received Cochlear Nucleus CI 24 implants and used an ACE processing strategy, one of a number of possible strategies used with the Nucleus implants.

Cochlear implants are different to hearing aids as hearing aids amplify sound while cochlear implants compensate for damaged sensorineural areas of the cochlea by bypassing some of the damaged areas. Coded electrical signals stimulate different hearing nerve fibres, which then send information to the brain (Cole & Flexer, 2007). Cochlear implants have become widely applied in cases where insufficient sound is available with hearing aids alone (Nicholas & Geers, 2007). Rapid
advancements continue to escalate in the field of hearing loss, with new developments such as the growing popularity of bilateral cochlear implants, and more sophisticated cochlear implant technology. Some children in this study had received bilateral cochlear implants towards the end of the study period.

1.5 EDUCATIONAL INTERVENTION

There is universal agreement that all children with hearing loss should develop language early in life as an effective means of communication between them and their parents (Gravel & O’Gara, 2003). A defining characteristic of specific educational interventions is the type of communication mode and its influence on the therapeutic approach (Martineau, Lamarche, Marcoux, & Bernard, 2001). Before parents choose an educational intervention for their child, a choice of communication mode is usually made. Traditional communication options for children with hearing loss include a range of choices from signed options to listening and spoken language options. Parent choice usually determines the choice of communication approach. Choice depends on a number of factors including the type of information presented to parents and how it is presented, the programs available in the child’s area, personal philosophies of parents and clinicians and how well the child is communicating already at diagnosis. In a review of the literature, Gravel and O’Gara (2003) consider that communication options can be represented on a spoken/visual language continuum. Figure 1 provides an adaptation of a diagrammatic representation of these options for the English language.
### Communication Options

<table>
<thead>
<tr>
<th>Spoken Language</th>
<th>Visual Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVT (AVT)</td>
<td>Cued Speech (cued language)</td>
</tr>
<tr>
<td></td>
<td>Manually Coded English</td>
</tr>
<tr>
<td></td>
<td>Australian/American Sign Language of the Deaf</td>
</tr>
<tr>
<td>Auditory-Oral (oral; auditory-oral, aural-oral)</td>
<td>Total Communication</td>
</tr>
<tr>
<td></td>
<td>Simultaneous Communication</td>
</tr>
<tr>
<td>Auditory-Verbal Education (AVEd)</td>
<td></td>
</tr>
</tbody>
</table>

---

**Bilingual-Bicultural**

*Figure 1.1 Diagrammatic representation of the communication options showing how each relates broadly to spoken language or visual language. Adapted from Gravel and O’Gara (2003)*

AVT facilitates the acquisition of spoken language through listening by newborns, infants, toddlers and young children with hearing loss. It promotes early diagnosis, one-on-one therapy, and aggressive audiological management and technology. Parents and caregivers actively participate in therapy. Through guidance, coaching and demonstration, parents become the primary facilitators of their child's spoken language development, and the parent must always be present in the individual child/parent sessions. AVT must be conducted in adherence to all 10 Principles of AVT (Alexander Graham Bell Academy for Listening and Spoken Language, 2007).

Since 2007 a new approach has been introduced called Auditory-Verbal Education (AVEd) (Alexander Graham Bell Academy for Listening and Spoken Language, 2007). Auditory-Verbal Education is an approach in which listening and spoken language skills and the interaction of parents are the emphasized. The Principles of Auditory-Verbal Education have been included as Appendix 1 to differentiate them from AVT. The main differences are that in Auditory-Verbal Education, parents need not be physically present and teaching can be in a group or individual. For further discussion see Section 1.6, p.11 and Appendix 1.
Cued Speech is a visual communication system which uses eight hand shapes in four locations (cues) in combination with the natural mouth movements of speech to enable all the sounds of spoken language to be distinguished from each other (National Cued Speech Association, UK, 2007).

The Auditory-Oral approach relies on optimal use of hearing technology, development of spoken language and integration into the hearing community. Traditionally, the Auditory-Oral approach encouraged the use of lipreading, facial expression and naturally occurring gestures. This approach teaches children with hearing loss to use their hearing in combination with lipreading and other cues to better comprehend and use spoken language. They can be taught individually or in groups, with the parent not necessarily being present (Moog, 2000).

Manually Coded English is a visual representation using signs and finger spelling of the spoken English language. Manually Coded English follows the grammar and syntax of the English language. Amplification is not necessary for a child using Manually Coded English, although it may be used (Gravel & O’Gara, 2003).

Total Communication is the combined use of oral, manual and visual modalities for communicating with and teaching children with hearing loss (Spencer & Marschark, 2005). The Total Communication approach is meant to be fluid, individualised, and context and situation dependent (Spencer & Tomblin, 2006).

Simultaneous Communication is a mode of communication sometimes utilised by children with hearing loss in which both spoken language and a manual version of that language (i.e. English and Manually Coded English) are used simultaneously. The difference between Simultaneous Communication and Total Communication is that use of hearing technology is not considered to be a component in Simultaneous Communication, whereas it is a key component in Total Communication (Gravel & O’Gara, 2003).

Sign languages are naturally evolved and complete visual languages with their own vocabulary and syntax. They are used by Deaf communities around the world and are usually specific to that community (Gravel & O’Gara, 2003). Bilingual/Bicultural is an approach where the sign language of the Deaf community is the first language learned, and is a means of acquiring a social identity within the Deaf culture and community, and this first language provides the foundations for the development of a second language in its literate form (Lynas, 1994).
The education approaches used in Australia include all options described above except for Cued Speech.

1.6 PRINCIPLES OF AUDITORY-VERBAL THERAPY (AVT)

The focus of the research in this thesis is on AVT. The Principles of AVT are to:

1. Promote early diagnosis of hearing loss in newborns, infants, toddlers, and young children, followed by immediate audiologic management and AVT.
2. Recommend immediate assessment and use of appropriate, state-of-the-art hearing technology to obtain maximum benefits of auditory stimulation.
3. Guide and coach parents¹ to help their child use hearing as the primary sensory modality in developing spoken language without the use of sign language or emphasis on lipreading.
4. Guide and coach parents¹ to become the primary facilitators of their child's listening and spoken language development through active consistent participation in individualized AVT.
5. Guide and coach parents¹ to create environments that support listening for the acquisition of spoken language throughout the child's daily activities.
6. Guide and coach parents¹ to help their child integrate listening and spoken language into all aspects of the child's life.
7. Guide and coach parents¹ to use natural developmental patterns of audition, speech, language, cognition, and communication.
8. Guide and coach parents¹ to help their child self-monitor spoken language through listening.
9. Administer ongoing formal and informal diagnostic assessments to develop individualized Auditory-Verbal treatment plans, to monitor progress and to evaluate the effectiveness of the plans for the child and family.
10. Promote education in regular schools with peers who have typical hearing and with appropriate services from early childhood onwards.

¹The term "parents" also includes grandparents, relatives, guardians, and any caregivers who interact with the child. (Adapted from the Principles originally developed by Doreen Pollack, 1970; endorsed by the AG Bell Academy for Listening and Spoken Language®, November, 2007).

Since 2007, the term “Auditory-Verbal Therapy” has been standardised by the AG Bell Academy to denote this approach, as previously the terms used were also “Auditory-Verbal approach” or simply “Auditory-Verbal”. Following the terminology standardisation, Certified Auditory Verbal Therapists became known as Listening and Spoken Language Specialists, Certified Auditory-Verbal Therapists (LSLS Cert. AVT®) and a newly named category of professionals,
introduced to designate the former “Auditory-Oral” practitioners who employ a greater focus on audition and parent involvement, has been created. These are known as Listening and Spoken Language Specialists, Certified Auditory-Verbal Educators (LSLS Cert. AVEd®) (Alexander Graham Bell Academy for Listening and Spoken Language, 2007). Because both categories have the term “Auditory-Verbal” in their title, and because of the need for clarity when comparing education options for future research, the difference between them is described below.

The main difference between AVT and AVEd is that in AVT, the parent is the main focus of the intervention. A parent (or caregiver) is always present with the child in AVT sessions, which are always individual, and training of parent and child takes place simultaneously. In comparison, in an AVEd session, the child is the main focus of the intervention, not the parent. The parent (or caregiver) may or may not be present (but must be involved), and the session may be group or individual (see the Principles of LSLS Auditory-Verbal Education in Appendix 1) (Alexander Graham Bell Academy for Listening and Spoken Language, 2007).

Despite the wide range of education options, there is a lack of controlled studies on the outcomes of any of these educational approaches, and there is an urgent need to provide a model for longitudinal research with the population of children with hearing loss, a group that typically exhibits many difficult-to-control variables. Also a benchmark for the rate of progressive development of children over a range of outcomes measures is critical for assessing if a child is progressing adequately. In addition, past studies based on a description of a particular program as “AVT” or “Auditory-Verbal” did not specify how the approach was operationalized in each program. Because one of the criticisms of research on educational options for children with hearing loss is the lack of description of the actual service delivery model used (Eriks-Brophy, 2004), this thesis attempts to further describe these variables in order to better evaluate and compare efficacy. Children may be self-selected in a program cohort based on success or failure in a specific program or approach, and an accurate description of the service delivery model becomes important when comparing the outcomes for children who start education in one type of program and then change, for various reasons, to another program.

1.7 AIMS OF THE THESIS AND OVERVIEW

This thesis aimed to measure the outcomes of an AVT program for children with hearing loss, compared with outcomes for a matched group of children with typical hearing (TH), through a longitudinal study.
Chapter 2 contains a literature review of research relating to language and speech outcomes for children with hearing loss educated in AVT programs (Dornan, Hickson, Murdoch, & Houston, 2008). This evidence is compared to available research for outcomes associated with other types of educational approaches. This review forms the basis of the research project described in this thesis. This research includes a study of speech perception for the AVT group over 50 months, and a longitudinal controlled study of the outcomes for speech perception, language, speech, reading, mathematics and self-esteem for a group of children with a mean severe hearing loss in an AVT program.

Chapter 3 outlines the research model, including research design, assessments used and method of analysis of data, and reports on the outcomes for language and speech for children with hearing loss in an AVT program, compared with those for a control group of children with TH, from the baseline (pretest) at the start of the study over a 9 month period (Dornan, Hickson, Murdoch, & Houston, 2007). This 9 month point in time is referred to hereafter as the 9 months posttest, and subsequent assessment points are referred to as the 21, 38 and 50 months posttests.

Chapter 4 reports on the outcomes for the AVT group over 21 months for speech perception, language and speech (Dornan, Hickson, Murdoch, & Houston, 2009). Speech perception is reported for the AVT group only. Speech and language outcomes for the AVT group are compared with those for the TH group.

Chapter 5 reports on the outcomes for the AVT group over 38 months, and includes assessments of speech perception, language and speech. Once again, speech perception outcomes are reported only for the AVT group. Language and speech outcomes are compared with those for the TH group. Chapter 5 also reports on and compares the outcomes for additional assessments of reading, mathematics and self-esteem, for the AVT and TH groups at the 38 months posttest.

Chapter 6 reports on the outcomes for the AVT group at the 50 months posttest for speech perception, language and speech (Dornan, Hickson, Murdoch, Houston, & Constantinescu, 2010). Speech perception outcomes for the AVT group are reported from the 38 months posttest to the 50 months posttest and are presented in Appendix 3 at the end of the thesis, as they were not included for publication. Language and speech outcomes for the AVT and TH groups are compared with those for the TH group from the baseline to the 50 months posttest. Chapter 6 also reports on and compares the outcomes for reading, mathematics and self-esteem from the 38 months posttest to the 50 months posttest for the AVT and TH groups.
Chapter 7 presents a summary and discussion of all results in relation to the research aims. It also describes the limitations of the research, the implications with respect to clinical practice, and provides direction for future research. Table 1.1 shows a summary of domains tested at each of the study assessment points.
Table 1.1 Domains tested and comparisons reported at various testing points in the study

<table>
<thead>
<tr>
<th>Assessments</th>
<th>Pretest</th>
<th>9 Months</th>
<th>21 Months</th>
<th>38 Months</th>
<th>50 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVT</td>
<td>TH</td>
<td>AVT</td>
<td>TH</td>
<td>AVT</td>
</tr>
<tr>
<td>Speech Perception</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Language</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Speech: Articulation of consonants in words</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Speech: Articulation of consonants in discourse</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Mathematics</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Self-esteem</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
CHAPTER TWO

Speech and Language Outcomes for Children with Hearing Loss in Auditory-Verbal Therapy Programs: A Review of the Evidence


2This chapter is an adaptation of the manuscript entitled “Speech and language outcomes for children with hearing loss in Auditory-Verbal Therapy programs: A review of the evidence”, published in the Communicative Disorders Review in 2008, and is inserted as accepted for publication, with the exception of formatting and wording changes to headings and figures to maintain consistency throughout the thesis, and with the inclusion of additional references published since 2008.
2.1 INTRODUCTION

The technological development of cochlear implants and digital hearing aids and the introduction of newborn hearing screening and new auditory signal processing techniques have afforded children with hearing loss new and unprecedented hearing potential. The recent upsurge in the implementation of the AVT approach to intervention and education for young children with hearing loss (Rhoades, 2006) has reportedly been driven by these technological advances (Ling, 2002). Progressively better speech and language outcomes for children in all types of education programs have resulted from increasingly more effective hearing technology, described by Geers (2005) as a “moving target” effect, which makes it inappropriate to compare later studies with earlier ones, and the available research has been compared with these challenges in mind. This paper aims to review recent research relating to the speech and language developmental progress of children with hearing loss educated in AVT programs.

2.2 BACKGROUND

The various education options for children with hearing loss include Bilingual/Bicultural, Total Communication, Cued Speech, Auditory-Oral and AVT approaches. Bilingual/Bicultural programs focus on education through two languages, such as sign language, the language of the Deaf, and English, where English is taught as a second language through reading, writing or sign (Easterbrooks, 2002). Total Communication is the combined use of aural, manual and oral modalities in communicating with and teaching individuals with hearing loss (Spencer & Marschark, 2005). Cued Speech is a visual communication system using eight hand shapes in four different locations, in combination with the natural mouth movements of speech, to make all the sounds of the spoken language look different (National Cued Speech Association, UK, 2007). The Auditory-Oral approach teaches children with hearing loss to use their residual hearing in combination with speechreading and other cues to better comprehend and use spoken language (Moog, 2000). With an Auditory-Oral approach, the typical delivery model is a classroom setting with groups of children with hearing loss (Schwartz, 1996). The education option of AVT is the application of techniques, strategies, conditions and procedures that promote acquisition of spoken language through listening, and is a one-on-one parent-centred approach (Estabrooks, 1994; 2005). This approach focuses on developing listening and spoken language through audition, using parents as the child’s natural language teachers (Alexander Graham Bell Academy for Listening and Spoken Language, 2007; Pollack, 1970).
Comparison of research studies on outcomes for children in the various education approaches is inherently difficult because of the large number of interacting variables that influence outcomes in the heterogeneous population of children with hearing loss (Eriks-Brophy, 2004). Among these variables are the characteristics of the education approach itself, plus other factors such as age of identification, audiological and education intervention, type of hearing device, cognitive ability, mode of communication, and aetiology, all of which may impact on outcomes for children with hearing loss (Calderon, 2000; Connor, Heiber, Arts, & Zwolan, 2000; Dowell, Dettman, Blamey, Barker, & Clark, 2002; Fryauf-Bertschy, Tyler, Kelsay, & Woodworth, 1997; Hammes, Willis, Novak, Edmonson, Rotz, & Thomas, 2002; Pyman, Blamey, Lacey, Clark, & Dowell, 2000; Sarant, Blamey, Dowell, Clark, & Gibson, 2001; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998).

The various types of education programs can have both obvious and subtle differences, in principles, strategies, techniques, therapeutic emphases, service components, expectations and assumptions (Goldberg & Flexer, 1993; Rhoades, 2006). All education interventions have the aim of allowing children with hearing loss sufficient language to be able to communicate. However, as Ling (2002) suggests, no single intervention program is suitable for all children who have hearing loss. Advances in hearing technology now make audition a possibility for most children with hearing loss, and these changes have resulted in increased emphasis on the listening and spoken language options of the Auditory-Oral and AVT approaches (Dornan, 1999; Ling, 2002). Nevertheless, there is very little high level evidence for the efficacy of any of the available education approaches (Gravel & O’Gara, 2003; Sussman, Duncan, Estabrooks, Hulme, Moog, & McConkey Robbins, 2004; Yoshinaga-Itano, 2004). This situation is not uncommon in the area of audiology or speech pathology research, as many of the most commonly used clinical approaches in these disciplines have never been objectively evaluated, nor the outcomes empirically documented (Eriks-Brophy, 2004). The focus of this review is on evidence regarding AVT, therefore this approach is described in more detail in the following section.

### 2.3 AUDITORY-VERBAL THERAPY (AVT)

The rigorous description of AVT was not addressed until 1993 when Auditory-Verbal International Inc. developed the 10 Principles of AVT. This was based on the original description of Doreen Pollack
These principles are to:

1. Promote early diagnosis of hearing loss in newborns, infants, toddlers and children followed by immediate audiologic management and AVT.
2. Recommend immediate assessment and use of appropriate, state-of-the-art hearing technology to obtain maximum benefits of auditory stimulation.
3. Guide and coach parents to help their child use hearing as the primary sensory modality in developing spoken language without the use of sign language or emphasis on lipreading.
4. Guide and coach parents to become the primary facilitators of their child’s listening and spoken language development through active, consistent participation in individualized AVT.
5. Guide and coach parents to create environments that support listening for the acquisition of spoken language throughout the child’s daily activities.
6. Guide and coach parents to help their child integrate listening and spoken language into all aspects of the child’s life.
7. Guide and coach parents to use natural developmental patterns of audition, speech, language, cognition and communication.
8. Guide and coach parents to help their child to self-monitor spoken language through listening.
9. Administer ongoing formal and informal diagnostic assessments to develop individualized Auditory-Verbal treatment plans, to monitor progress and to evaluate the effectiveness of the plans for the child and family.
10. Promote education in regular classrooms with peers who have typical hearing and with appropriate support services from early childhood onwards.

The term “parents” also includes grandparents, relatives, guardians and any caregivers who interact with the child. The principles also state that, for a program to be labelled as using an AVT approach, this necessitates the implementation of all ten principles.

Although a particular AVT program may adhere to all 10 of these principles, other education approaches may include some or all of them. For purposes of research on the outcomes for children enrolled in a specific AVT program, outcomes studies need to specify more details of the operational
model employed. The lack of this detailed information has been a criticism of AVT outcomes research (Eriks-Brophy, 2004) as well as outcomes research on other options. Definitions of different education approaches for children with hearing loss have typically been nonspecific and general in nature. Definitions of some oral options in particular have recently been changed following the transition of Auditory-Verbal International, Inc ®, to the Alexander Graham Bell Association for Deaf and Hard of Hearing. The new conjoint body was called the AG Bell Academy for Listening and Spoken Language® (2005), and its function is international certification of professionals. In November 2007, the Alexander Graham Bell Academy also developed 10 principles for a new category of intervention, with Auditory-Verbal Education which recognised the improved outcomes made possible by the cochlear implant and newborn hearing screening, and the changing focus of auditory-oral intervention towards the development of spoken language through audition (Alexander Graham Bell Academy for Listening and Spoken Language, 2007). In this review, the term “Auditory-Verbal Therapy” (AVT) will be used to describe the approach studied and includes the studies prior to November 2007 referring to the “Auditory-Verbal approach” or “Auditory-Verbal practice”. As this is an early intervention approach, the child leaving the program to attend school is usually seen as “graduating”, although this term is not well defined in research papers.

In the past, the major difference between AVT and other approaches has been its emphasis on developing spoken language through audition using parents as facilitating partners (Beginnings, 2008). Today, the major differences between AVT and approaches that seem similar (in particular the Auditory-Oral approach) are requirements that the parent (or the main caregiver) must be present at each education session, and that the session must be individual for the child and parent/main caregiver) (Alexander Graham Bell Academy for Listening and Spoken Language, 2007). This is in contrast to other types of education approaches in which it is not mandatory for the parent to be present, and a session may take place in a small or large group, or be individual. Despite the use of the 10 principles to ensure consistency across settings, there has been an issue that research based on a description of a particular program as “AVT” or “Auditory-Verbal” did not specify how the approach was operationalised. This review attempts to further detail the variables which may better describe a cohort of children in a particular program in order to evaluate and compare outcomes for these programs. This factor is significant when a particular cohort being studied includes children who start education in one type of program or education approach and then change, for various reasons, to another program or education approach. In such a case, children may be self-selected in a program cohort based on their success or failure in the program. In order to
evaluate and compare outcomes, research studies need to be evaluated according to the principles of evidence-based practice.

### 2.4 EVIDENCE-BASED PRACTICE

The many changes in the treatment of children with hearing loss have necessitated the need for objective, quantifiable evidence, as clinical practice needs to be efficacious, effective, accountable, viable, equitable and acceptable (Crombie & Davies, 1996). Evidence-based medicine is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients. The practice of evidence-based medicine is integrating clinical expertise with the best available clinical evidence from systematic research (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996). Crombie and Davies (1996) state that to allow evidence-based practice, it is necessary to present information from studies that are well designed and of sufficient size to answer worthwhile research questions, while employing adequate care to protect the rights of patients. The question is what types of evidence are desirable for evidence-based practice for the treatment of hearing loss in children? Eriks-Brophy (2004) maintains that the best evidence requires a high degree of scientific methodological rigour in conducting outcomes research that contributes to the strength of evidence it provides through the use of controlled research designs. This provides protection against bias and subjectivity in the interpretation of the findings, and protects the rights of participants. Eriks-Brophy discusses a proposed classification system for outcomes studies on communication interventions (Fineberg, 1990; Fratalli, 1998; Holland, Fromm, De Ruyter, & Stein, 1996). These categories are supported by those proposed by the Oxford Centre for Evidence-based Medicine (2001). The three categories, or classes of evidence, starting with the highest level of evidence are:

- **Class I** – well-designed experimentally controlled studies, usually randomized control trials involving large numbers of subjects assigned to random groups. Studies should include multiway sensitivity analysis with a minimum of 30 subjects each for experimental and control groups. The results should indicate significant differences between groups and reliable narrow confidence intervals (Guyatt & Rennie, 2002). Ideally, participant groups should be enrolled at the same point in intervention, and have similar points of diagnosis and amplification, with control over a number of major variables which have been found to be influential on outcomes;
- Class II – quasi-experimental designs, often in the form of cohort studies or program evaluations. Cohort studies are prospective studies following a group of individuals over time to examine particular outcomes, which may involve a control group for comparison and may have limited generalisability;

- Class III – typically non-experimental research designs, which are often retrospective questionnaires or surveys, case studies, data base studies, group judgements or expert opinions of performance.

Eriks-Brophy (2004) points out that while Class I evidence is the highest form of evidence, it may be clinically unobtainable or unethical in clinical speech-language applications for children with hearing loss as it is not possible to assign children to different treatment groups. Parents have the right to make the decision regarding which type of education approach they want for their child. Therefore, Class II evidence is viewed as the most appropriate level of evidence in this field. High quality studies would involve large groups, include a control group for comparison and have the other hallmarks of scientific rigour (e.g. use of standardised assessments, blinding of outcomes assessors). Designing appropriate research studies that protect against bias and subjectivity in the interpretation of findings ensures a high degree of scientific methodological rigour, which contributes to the strength of the evidence it provides in support of a treatment approach (Eriks-Brophy, 2004; Oxford Centre for Evidence-based Medicine, 2001; Rhoades, 2006). This review of the literature relating to outcomes of AVT programs aims to report on the strengths in the literature and to point to gaps and weaknesses in the evidence, leading the way to relevant future research.

2.5 EVIDENCE FOR OUTCOMES OF AVT

A number of researchers have concluded that AVT provides a viable option for many children with hearing loss, even those who have severe or profound hearing loss (Dornan, Hickson, Murdoch, & Houston, 2007; Durieux-Smith, Eriks-Brophy, Olds, Fitzpatrick, Duquette, & Whittingham, 2001; Easterbrooks, O’Rourke, & Todd, 2000; Goldberg & Flexer, 2001; Rhoades, 2001, 2006; Rhoades & Chisolm, 2001; Robertson & Flexer, 1993; Wray, Flexer, & Vaccaro, 1997). However, much of the evidence pertaining to the linguistic attainment of children using Auditory-Verbal practice is sparse and incomplete (Pollack, Goldberg, & Caleffe-Schenck, 1997) and more high-level evidence is required
(Eriks-Brophy, 2004; Rhoades, 2006). This section describes the available evidence provided by the published studies, starting with Class III evidence, including survey studies and case studies, then continuing on to Class II studies, finishing with those which provide the highest level of evidence to date.

2.5.1 Class III Studies

Retrospective survey studies and case studies are prominent in the early literature concerning AVT. Rhoades (2006) reported that five major retrospective studies, which were published in peer-reviewed journals (Easterbrooks, O’Rourke, & Todd, 2000; Goldberg & Flexer, 1993; 2001; Wray, Flexer, & Vaccaro, 1997; Robertson & Flexer, 1993), have significant limitations due to the lack of standardised assessment instruments employed, the anecdotal nature of the data, the lack of control groups, and the fact that the samples studied possibly represented self-selected groups. In one of these large retrospective studies, Goldberg and Flexer (1993) surveyed adults at least 18 years old who had attended AVT programs in the United States and Canada for at least 3 years when young. Surveys were initially sent to professionals in charge of AVT programs who were instructed to send them to every person who fit the age and time of attendance criteria. “Graduates” were identified by a therapist who had taught at the program, and were defined as those individuals who had attended the program for the required 3 years. Participants included all who met the criteria, not just the “stars”. A total of 157 people were surveyed (response rate 43%). The majority (94%) of the participants were hearing aid users with severe-to-profound or profound hearing loss. Eighty-six percent had gone on to attend mainstream education classes at high school level, and 95% had carried on to some type of post-secondary education. They identified themselves as successfully functioning in three areas: community, local school and post secondary institutions. Three quarters of the respondents replied that they saw themselves as being part of the “hearing” world. In 2001, Goldberg and Flexer published a follow-up study to this initial 1993 study, with a 36% response rate and 114 participants, and reported a high degree of consistency to the original findings, with 91% of participants being mainstreamed in their senior high year. The limitations of this research include the retrospective nature of the studies, relying on memory and client records, and the lack of consistent standardised assessments used. Furthermore, few of these participants received the benefits of cochlear implantation at an early age, even though 94% had a severe to profound hearing loss, which makes the findings hard to generalise to the population of children with hearing loss today.
Another retrospective survey study by Easterbrooks, O’Rourke, and Todd (2000) attempted to define the factors associated with success in an AVT program by analysing data over 10 years from children who had attended. Seventy-two children with hearing losses ranging from mild to profound who had attended a particular AVT program were included. The sources of information were the clinic files, questionnaires, and parent reports. Parents were also asked to report on whether their child had “graduated” from the program, or whether they left the program as a result of dissatisfaction. The term “graduate” was not defined in detail. The factors associated with success in an AVT program were found to include being female; coming from an affluent white American family; and remaining in the program until after graduation from the AVT program to attend mainstream school. The survey also showed 57% of the children who remained in the program for over a year continued on to be fully mainstreamed after graduation, and had less than a one-year gap between their language age and chronological age. A problem with this study is the fact that the socioeconomic background of this group may have caused the sample to have a self-selection bias. Also, the nature of the AVT program was not defined, making comparisons with other studies difficult.

Several Class III survey studies have been performed focussing on the domain of reading skills. Robertson and Flexer (1993) conducted a survey asking parents to provide standardised test scores for reading development for their school-aged children and included a parent questionnaire on their perception of their child’s reading progress. Results were gathered from 37 children with hearing loss (aged 6 to 19 years) who had prelingual hearing loss and were educated using AVT in clinics either in the United States or Switzerland. Thirty of the children scored at the 50th percentile or higher on a battery of reading tests normed on children with normal hearing. The authors concluded that the children developed reading skills commensurate with their hearing peers. However, as the reading measures were variable, anecdotal (relying on parental report), reported retrospectively, and the study included many demographic and child-specific variables among the population (age, fitting of hearing device etc.), it is difficult to fully interpret these results. A description of the centres that the children attended and the operational model of the programs were also not recorded.

In another survey study by Wray, Flexer, and Vaccaro (1997), academic performance was targeted. Mainstream classroom performance of 19 children with hearing loss who had used AVT at a particular preschool clinic (when they were aged 2 to 5 years) was assessed using a survey of teachers of the children (5.5 to 15.2 years of age at the time). The Screening Instrument for Targeting Educational Risk
(SIFTER) (Anderson, 1989) was used to assess teacher’s perception of a student’s performance in academics, attention, communication, class participation, and school behaviour, through 15 rated questions. In addition, parents reported on reading level, and classroom and support services for their children. The authors found that 16 of the 19 children were fully included in their local schools and, according to teacher report, read at grade levels or above. However, this study is limited by the fact that no normative data is included with the SIFTER apart from a cut-off score indicating that a student may be experiencing difficulties in the classroom.

A study performed by Wu and Brown (2004) provides Class III evidence involving multiple centres. A set of questionnaires was given to parents and teachers of children (mostly preschoolers) who had received AVT from between 1 to 80 months, and used either cochlear implants or hearing aids. Included in the study were 20 parents and eight Auditory-Verbal Therapists who were from three AVT programs. The questionnaires included a rating of the expectations of both parents and teachers, for the child’s performance, and for parents’ and teachers’ expectations. An additional questionnaire given to the teachers was a checklist of the child’s receptive and expressive language adapted from the Receptive-Expressive Emergent Language Scale (REEL) (Bzoch & League, 1978). The results showed that high adult expectations of language progress were maintained throughout the study, and that these high expectation levels were related to rate of language growth. However, data on the language levels was obtained retrospectively from a teacher response checklist, not on actual results on common standardised assessments, resulting in problems with interpreting the results of the study.

Duquette, Durieux-Smith, Olds, Fitzpatrick, Eriks-Brophy, and Whittingham (2002) collected data on participants aged 14 to 30 years, using questionnaires and focus groups. These participants had hearing loss ranging from mild to profound; approximately half had severe to profound deafness. All participants had received AVT intervention for a mean of 2 years from the same program. When the data was collected, the individuals (mostly at high school) were aged between 14 and 30 years. Records from school or parent reports showed that the participants scored within the average range on measures of communication, academic skills and self-perception as compared to their peers with normal hearing. Sixty five percent were fully integrated for all of elementary and high school (Durieux-Smith, Eriks-Brophy, Olds, Fitzpatrick, Duquette, & Whittingham, 2001). Once again, few participants in this study received the benefits of cochlear implantation at an early age. However, because this data was gathered
retrospectively and included parent reports as well as information from assorted assessments, some difficulties in interpretation of the results arise when comparing with other studies.

All of these Class III studies, while showing promising results for particular groups of students, relied on parent or child memory or on reporting from a file and are therefore retrospective and anecdotal. They mainly cover gross domains rather than specific abilities and no control groups were included for comparison.

In addition to surveys, case studies have also provided some limited evidence for the AVT approach. For example McCaffrey, Davis, MacNeilage, and von Hapsburg (1999) investigated the audiotape-recorded spontaneous speech of one young child with profound bilateral hearing loss, who received a cochlear implant at 24 months of age and was enrolled in an AVT program. The child’s speech was repeatedly analysed pre-implantation to 32 months of age. It was found that the child’s speech initially showed few canonical syllables, mostly nasal phonemes and stop consonants with some mid-central vowels. Speech then progressed to include variegated and reduplicated canonical babbling and two word combinations in expressive language when tested pre-implant and at 2, 7 and 9 months post-implant. Also, in an extension to this same longitudinal case study, Warner-Czyz, Davis, and Morrison (2005) found that speech volubility, phonetic inventory and lexical targets for the child showed significant progress, similar to normal development. Such case studies provided very limited evidence for the education approach as many other factors may explain the child’s performance.

Overall, although none of these Class III studies provide strong evidence for AVT efficacy, they demonstrated the potential for speech and language development with this approach, and led the way to developing studies that provide higher levels of evidence.

### 2.5.2 Class II Studies

A higher level of evidence was provided by the first experimental study of AVT, reported by Rhoades and Chisolm (2001) and Rhoades (2001). Assessments standardised on children with normal hearing were used on a heterogeneous group of 40 children with hearing loss who had received AVT from 1 to 4 years, and had started at a mean age of 44 months in an AVT program. The tests were repeated over the next 4 years for those remaining in the program. The language measures used were the Sequenced Inventory of
Communication Development (SICD) (Hedrick, Prather, & Tobin, 1984), the Preschool Language Scale-3 (PLS-3) (Zimmerman, Steiner, & Pond, 1992), and the Oral-Written Language Scale (OWLS) (Carrow-Woolfolk, 1995). All of these measures have documented psychometric properties and are commonly used to assess the language of preschool and school children. Average group performance in receptive and expressive language showed 12 months progress over 12 months of time, that is, the same rate as children with normal hearing. It was noted that the children’s receptive language progressed faster than expressive language during the first 2 years of intervention, and then their expressive language growth rate increased in the third and fourth years of intervention. At “graduation”, the mean results for the group (14 children) showed that the gap between chronological age and language age had closed, so that language ability was commensurate with peers with normal hearing. The term “graduation” was defined as “professionally released” in this study, but this term needs a more detailed definition to make it potentially comparable to other studies. A further limitation of this study is the fact that no comparison group was included; children may have shown the same progress after using other forms of intervention. Also, although this study specified how many children did not stay in the program (30%), the reasons for leaving were not adequately described. If the children who did not stay exited because their development was not as strong as the children who did stay, then the reason that all of the children who did stay achieved age level development may be due to self-selection. Rhoades and Chisolm (2000) comment that as the parents are a well-educated group it may not be possible to apply the findings to a group of children with hearing loss who have parents with less education. It is possible that the positive results could be related to the children coming from higher income families who are able to access private therapies for their children (such as AVT programs).

One Class II study, which did allow direct comparison of children in an AVT program with children with normal hearing, was reported by Duncan (1999) and also Duncan and Rochecouste (1999). These authors compared the length and complexity of utterances produced by four and five year old children with hearing loss in an AVT program to those of their peers with normal hearing. Both groups were enrolled in the same integrated setting. They found that utterance length and morpheme usage varied within and between groups, with the children with hearing loss exhibiting a lower mean length of utterance and providing fewer samples of bound morphemes for both age groups. Although full details of statistical analysis are not recorded, the authors concluded that there were fewer differences between the results for the two groups of 5 year olds than the two groups of 4 year olds, indicating that the children with hearing loss may have been moving towards narrowing the gap between chronological age and
language age for these skills. Duncan (1999) also reported that, for the same population, there were no significant differences between groups for the majority of conversational skills. However, these results have limitations that must be considered, including: matching for chronological age instead of language age; lack of matching for gender or socioeconomic status or other variables; small sample size (11 in the Duncan study and 13 in the Duncan and Rochecouste study); and lack of statistical details of the analysis. Matching children with hearing loss with children of the same age with normal hearing means that different cognitive levels caused by differences in language levels could influence the results. It has been reported in the literature that there is a significant positive correlation between both verbal and nonverbal intelligence and language ability (Remine, Brown, Care, & Rickards, 2003). Gender is also a significant variable, which would be appropriate to match in a control group, as rate of speech and language development for males and females can vary, with females showing an advantage (Fenson, Pethick, Renda, Cox, Dale, & Reznick, 2000). In addition, as higher socio-economic status can result in enhanced language development for children with hearing loss through increased levels of family involvement, matching of this variable is also important. Moeller (2000) has identified that high levels of family involvement correlate with positive language outcomes for children with hearing loss, and conversely, limited family involvement correlates with significant language delays at 5 years of age, especially when enrolment in an intervention program is late.

Hogan, Stokes, White, Tyszkiewicz, and Woolgar (2008) studied 37 children in a British AVT program with the intention of contributing information that could assist parents to make informed choices. The Preschool Language Scale-3 (PLS-3) (Zimmerman, Steiner, & Pond, 1997) adaption for the UK was given to a heterogeneous group of children at entry to the study and at 6 monthly intervals. Progress of language development was measured by predicting language scores in the absence of AVT according to a model, and comparing this with actual rate of language development. They found that the children developed language at the same rate, and in many cases in advance of their hearing peers according to the predicted model. The authors admitted that there are limitations to the study, including the small numbers of children in the different categories of hearing loss, the fact that a model was used instead of actual test results on a control population, and the model predicted scores in a linear fashion not always found in an actual population.

Another Class II study is a longitudinal study on the outcomes of an AVT program that was conducted on a sample of 29 Australian children with a mean age of identification of 24.6 months
The children had, on average, severe to profound hearing loss and were 2 to 6 years old at the commencement of the study. Around half wore hearing aids and half had cochlear implants. A control group of children with normal hearing who were matched for initial language age, receptive vocabulary, gender, and socio-economic level (based on head of the household’s highest level of education reached) was used for comparison. Both groups of children were assessed on a range of speech and language measures at the start of the study and 9 months later. These assessments included the Preschool Language Scale-4 (PLS-4) (Zimmerman, Steiner, & Pond, 2002) or Clinical Evaluation of Language Fundamentals-3 (CELF-3) depending on the child’s age, (Semel, Wiig, & Secord, 1995), the Peabody Picture Vocabulary Test (PPVT-3) (Dunn & Dunn, 1997), and the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 2001). Results showed that both groups made statistically significant developmental progress in speech and language over the 9-month period and there was no statistically significant difference between groups in terms of rate of progress on all assessments. At the end of the study, 72.4% of children with hearing loss scored within or above the age appropriate range for total language age. Three children with hearing loss left the program during the study period, including one who relocated out of the country, and two who were identified with major other disabilities and transferred to another program. Thus, the results were influenced by this selection bias. Nevertheless, this study provides a higher level of evidence than previous studies of AVT outcomes that were retrospective and/or based on single case studies (Oxford Centre for Evidence-based Medicine, 2001). However, limitations of the Dornan et al. (2007) study were identified and include the short-term nature of the follow-up and the relatively small sample size. This study has now been continued longitudinally, and the ongoing results will be reported at later dates. Furthermore, as some studies on outcomes of AVT reported potential for literacy development for children with hearing loss educated using this approach (Robertson & Flexer, 1993; Wray, Flexer, & Vaccaro, 1997), assessments for literacy and also mathematics have been added to the longitudinal assessment protocol of this study. In addition, because Eriks-Brophy (2004) has noted that there are currently no studies which investigate the self-perception and personal adjustment of children using AVT, a self-esteem measurement has been included in the later stages of the longitudinal study. The research approach described in the study is potentially applicable to children attending other AVT programs, or being educated in other types of approach.
2.5.3 Summary of Evidence

In summary, there is only minimal Class II evidence for AVT, and a great need for future rigorous longitudinal research. The earlier Class III studies served their purpose in directing attention to the outcomes possible for some children using this approach. It must be acknowledged that Class I evidence, or the highest rated type of clinical evidence (Oxford Centre for Evidence-based Medicine Levels of Evidence, 2001) will never be possible for studies on AVT, as it is parents, not clinicians or researchers, who have the right to choose an education approach and a program for the child (Eriks-Brophy, 2004; Rhoades, 2006). As such, it is unethical to randomly assign children to treatment groups. However, it is possible to analyse the weaknesses in the methodology and scope of the available research in order to plan strategies for strengthening the evidence considerably, as discussed in the later section on future research needs.

2.6 WEAKNESSES IN EXISTING EVIDENCE

When trying to compare the outcomes of AVT with other education approaches, it is necessary to examine the weaknesses in the studies on these approaches as well. On examination, the problems are very similar to those pertaining to the AVT studies and many commonalities in issues become apparent. Research in the area of health services is inherently difficult because researchers are unable to withhold treatment to children in order to carry out randomized controlled studies. Also lack of control of many variables, the need for ethical approval, time constraints and the involvement of other professionals outside the discipline being studied all impact on the ability to provide high level evidence. Research in the area of paediatric hearing loss is particularly difficult. Not only is this a relatively low incidence disability, Rhoades (2006) has described the area of hearing loss as the “divisive cultural-communicative landscape of deafness” and notes that objectivity is even more critical in this type of research. The problems with the existing evidence on AVT are discussed in four main areas: research methodology used; measurement of outcomes; population of children studied; and differences in interventions.
2.6.1 Research Methodology

The major problems with existing studies on AVT, and indeed on other education approaches, include the lack of rigour in the research methods, lack of control groups, study designs that are retrospective and anecdotal instead of experimental in nature, and bias caused by lack of independent assessors. Also few studies detail the characteristics of the intervention itself, and although AVT does have defining principles that approach a “standardization” of this education option, different programs may interpret these principles somewhat differently, which leads to different operational practices.

In addition, the effects of hearing device and intervention are often confounded, particularly in studies where the intervention is not the focus of the research design. For example, Geers, Nicholas, and Sedey (2003) attempted to measure the effect of the intervention by proxy report, but the study was not designed to directly measure the intervention. Also, children often received a cochlear implant at some time during the studies, making research on the intervention even more problematic. There is a lack of consistent and standardised research measures across studies, with many inconsistencies regarding measurement of outcomes.

2.6.2 Measurement of Outcomes

A wide variety of communication skills are measured across studies, and there are few studies that involve the measurement of a battery of various skills across a number of domains. Difficulties in comparison of outcomes also occur when considering research on education approaches, because some researchers use speech and language tests to document progress. These assessments were developed to measure performance at one point in time and not necessarily to document progress over time. Also some studies investigate speech and language outcomes at one point in time only, whereas others report on rate of progress for these skills over a particular period, usually either by the change in the time gap between chronological age and language age, or by the rate of development over time as compared to children with normal hearing. Whether the gap between chronological age and language age decreases, stays the same or increases over time has been used to express rate of developmental progress of speech and language skills for children with hearing loss. Before the implementation of universal newborn hearing screening, which now allows more children to reach age-appropriate levels of language (Yoshinaga-Itano,
Sedey, Coulter, & Mehl, 1998), a considerable gap between chronological age and language age for the level of development of speech and language for children with hearing loss continued to be reported as the child with hearing loss developed, whatever the chosen communication approach (Blamey, Barry, Bow, Sarant, Paatsch, & Wales, 2001; Moog & Geers, 1995). Having no chronological age and language age gap shows a positive benefit for the intervention. An example of this was in the Rhoades and Chisolm (2000) study on a group of children in an AVT program. Fourteen of the children who stayed in the program until they entered mainstream school showed no significant difference between mean chronological age, receptive language age and expressive language age (plus or minus one standard deviation), indicating there was no gap between these parameters. Likewise, Easterbrooks, O’Rourke, and Todd (2000) found that children in an AVT program who progressed to professional release at the age of school entry had a chronological age and language age gap of less than one year. These results could be contrasted with those of Yoshinaga-Itano (1999) who found that, for children on a variety of education approaches, a delay in language at 12 months of age in children with significant hearing loss educated in both signed communication and oral communication classes persisted until seven years of age. However, direct comparisons between studies are difficult because of methodological issues, particularly the lack of control groups, the different parameters measured, lack of definition, and small numbers in the Rhoades and Chisolm (2000) study on AVT.

In some of the research studies focussing on rate of progress, outcomes for children with hearing loss were compared to the children’s predicted scores, to peers with normal hearing of the children’s chronological age or occasionally to a control group. When examining growth rates over time, several studies have shown that rates of language growth for some children who receive an implant before age five years were close to the growth rates of children with normal hearing once the child had received an implant (Kirk, Miyamoto, Lento, Ying, O’Neill, & Fears, 2002; Robbins, Koch, Osberger, Zimmerman-Phillips & Kishon-Rabin, 2004; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000).

Even though variability in outcomes is generally acknowledged throughout the literature, few studies conducted investigations into characteristics that may affect the rate of a child’s progress. The results of the reviewed studies that investigated mean rate of developmental progress for any particular group of children with cochlear implants were variable. They ranged from between half to two thirds the rate of hearing peers in one study by Blamey, Barry, Sarant, Paatsch, Bow, and Wales (2001) to one and a half times the rate of hearing peers for the first six months after implant in another study by Robbins,
Bollard, and Green (1999). However, the above studies are not comparable either in the type of participants or the statistical models used to analyse the data. For example, the language growth rates described in the Robbins et al. (1999) study was for children receiving a cochlear implant who were tested before implant and 6 months post implant. This study is not directly comparable to the hierarchical linear growth curve models used in the Blamey et al. (1999) study which required large numbers of subjects and multiple measures across a longer period of time. In this latter study, however, there is a great attrition rate of participants and only a few of the original participants are included in the six months post study. Because the study does not compare the growth to typical age-matched peers as in a control group, it is difficult to interpret the results. The different characteristics of the population studied also add yet more variables, which confound comparative research.

2.6.3 Population of Children Studied

The many variables inherent in a population of children with hearing loss make research on this population fraught with difficulty. For studies to be comparable, they need to match the other studies in as many variables as possible. Few studies on outcomes of AVT are directly comparable with studies of outcomes of other approaches as there are too many variables involved, many of which are either unreported or unable to be compared because they are described using different parameters.

Although evidence of positive outcomes for children with hearing loss resulting from early identification and intervention is mounting (Calderon, 2000; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998), there is also evidence that a wide range of other diverse factors influence outcomes and therefore need to be controlled in research. These factors include age of identification, level of hearing loss, hearing devices fitted, education intervention, education setting, mode of communication, cognitive ability, presence of other disabilities, age at testing, aetiology, gender, socio-economic status, family structure and involvement, maternal characteristics, ethnicity, and presence of other disabilities (Gravel & O’Gara, 2003).

Recent outcomes studies have included many children with cochlear implants, and a variety of outcomes have been found. A feature of this research is that for children educated in a range of different education settings (both signing and oral) there have been improvements in speech and language skills post implantation, with a wide range of individual performance (e.g. Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006; Szagun, 1997; Yoshinaga-Itano, 1999). The technology available at the time
that studies are carried out is also of significance. Historically, in earlier studies of children with cochlear implants who used Total Communication or Oral Communication approaches, similar and impressive language benefits from cochlear implants are shown (e.g. Connor, Heiber, Arts & Zwolan, 2000; McConkey Robbins, Svirsky, & Kirk, 1997; Robbins, Bollard, & Green, 1999). However in the majority of the most recent large studies examined, it has been reported that children with cochlear implants who use Oral Communication consistently achieve significantly higher levels of speech perception, receptive and spoken language and speech intelligibility than children using Total Communication (Connor, Heiber, Arts, & Zwolan, 2000; Cullington, Hodges, Butts, Dolan-Ash, & Balkany, 2000; Geers, Nicholas, & Sedey, 2003; Hodges, Dolan-Ash, Balkany, Schloffman, & Butts, 1999; Kirk, Miyamoto, Lento, Ying, O’Neill, & Fears, 2002; Miyamoto, Kirk, Sehgal, Lento, & Wirth, 1999; Nicholas & Geers, 2007; Osberger, Zimmerman-Phillips, & Fisher, 2000; Sarant, Blamey, Dowell, Clark, & Gibson, 2001; Stacey, Fortnum, Barton, & Summerfield, 2006; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000; Tobey, Geers, Brenner, Altuna, & Gabbert, 2003; Tobey, Geers, Douek, Perrin, Skellett, Brenner et al, 2000; Young, Grohne, Carrasco, & Brown, 2000). These outcomes highlight the need for a historical view when comparing research studies. Even so, care must be taken in designing studies as the outcomes for speech and language for children in Oral Communication programs have improved over time. This improvement may relate to advances in technology or the longer periods of experience with a cochlear implant, which may have helped to develop the long-term speech and language outcomes for children. However the larger numbers of children and the extended time span for speech and language outcomes to develop following implant gives weight to these more recent studies. Results should be interpreted with caution, however, because of the difficulties in comparing studies. It is likely that the dimensions of the qualities that may impact on outcomes are unequal, making comparisons even more difficult.

Age of identification of the hearing loss has been found to be highly predictive of outcome in almost all of the approaches used with children with hearing loss (Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998), although this is often not reported in studies. Similarly, the influence of parent education and socioeconomic status warrants further discussion. Many studies on cochlear implantation and outcomes for children have found that the level of family income is one of the strongest predictors of success (Connor & Zwolan, 2004; Geers, Nicholas, & Sedey, 2003; Tobey, Geers, Brenner, Altuna, & Gabbert, 2003; Wake, Poulakis, Hughes, Carey-Sargeant, & Rickards, 2005). Connor and Zwolan (2004) point out that low socioeconomic status may be associated with reduced academic opportunity, underachievement, unstable housing, family stress, health problems and single parent families. Almost all
of the studies on outcomes of AVT report that the parents of the children come from a well-educated group, and these parents would have access to private therapies. For example, in the Rhoades and Chisolm (2001) study, 77% of the parents had bachelor’s degrees or higher, suggesting a possible socioeconomic status bias. Similarly, in the study by Dornan, Hickson, Murdoch, and Houston (2007), all but one of the parents were educated beyond a high school level, and this higher proportion of educated parents in AVT programs was also noted by Easterbrooks, O’Rourke, and Todd (2000). However, although many of the AVT programs are fee-paying, a number exist that are not-for-profit centres with no or minimal fees payable. The question of whether AVT is only available to the affluent, or whether affluent families have more information, or more access to them, is an unsolved one and a weakness in the evidence that needs to be addressed in the future. Consequently, whether AVT is effective across a broader range of families is an important empirical question for future research. It may also be that children in AVT programs have higher cognitive skills because of higher socioeconomic levels. If participants from other education approaches were selected only for high cognitive ability, high income and high level of education of the parents and comparisons of outcomes were made, it may be possible that no differences would be found. This is a potential reason for the fact that, in a few studies, method of communication has not been found to be a significant variable when statistical control of these and other relevant variables were possible (e.g. Wallis, Musselman, & Mackay, 2004). However, here again, there is very little high quality, high-level evidence. Cognitive skills are seldom controlled for or reported in studies. Often if there is a control group, how similar the control group is on these critical variables is usually not studied or reported. One of the significant weaknesses in the literature on AVT is the lack of outcomes evidence for a range of different populations.

Choice of a child’s education program may be a function of parent choice, according to geographic availability of programs, or the level of a child’s speech perception skills, and these variables are not normally noted in studies. Other typical issues with the population studied include small sample sizes, lack of detailed descriptions of interventions studied or lack of definition of terms, and self-selected or convenience selected samples. Often, no clear inclusion criteria are presented. Furthermore, few of the studies report on an analysis of children who dropped out of the program, or give a description of the characteristics of the cohort studied.
2.6.4 Differences in Intervention

One of the strengths of the Auditory-Verbal approach is the consistent training of the professionals, and clear documentation about how to practice this approach. However, the lack of adequate description of the treatment used in the studies to ensure the fidelity of the program as an Auditory-Verbal program is a major criticism that prevents generalising of results. In particular, few studies attempt to characterize the intervention into different qualities (e.g. frequency of intervention, quality, communication mode, and family involvement). Issues that play a significant role in the comparison of education programs, but are seldom recorded, are the number of sessions per week, whether the child began with a particular approach initially and remained with that approach, or whether, as is often the case with children in signing programs, they began in oral programs but were unsuccessful and therefore changed approaches. In such cases there is a normal selection process for some communication approaches that tend to retain children with the greatest success, because children who succeed usually maintain involvement with the program over time. Failure to state whether the terminology used is a description or an underlying philosophy is an area of confusion, as these differences are not always stated explicitly (Spencer & Tomblin, 2006). As well, it is often unclear if the communication mode used in a particular research study is that used by the child normally, or whether it accurately reflects the child’s preferred communication approach. Definitional ambiguity and variability is common across the literature on childhood hearing loss (Currie, Menakaya, Parkhill, Patten, & Voutier, 2005), as is lack of clarity of descriptions in general, or in the definition of commonly used terms in an intervention program, such as “graduate”.

2.7 SUMMARY

The literature on the speech and language outcomes of various education approaches for children with hearing loss has many weaknesses. However it shows broadly that children receiving forms of education other than AVT also experience positive benefits, and, with modern hearing technology like cochlear implants, these benefits are greater for children in oral programs than programs that include signing. The reason for this is most likely multifactorial and warrants further investigation. It may actually be that the very characteristics that need to be controlled when comparing one method of communication or education approach with another are impossible to control. Even though the literature does indicate that there are a number of children who have been very successful in Auditory-Oral and Auditory-Verbal Therapy approaches, the evidence to date does not demonstrate the superiority of any
single education approach. Overall, the literature provides some minimal but increasing evidence to support positive outcomes using an Auditory Verbal Therapy program for children with hearing loss. It also provides many positive indicators for the directions of future research.

2.8 FUTURE RESEARCH NEEDS FOR AVT

To increase the level of evidence on Auditory-Verbal Therapy, research should include prospective multi-dimensional, longitudinal studies with large sample sizes. These larger samples should now become available with the increase in popularity of the approach. The addition of a control group of children with normal hearing matched for as many parameters as possible would allow more conclusions to be made about the efficacy of treatment for different populations of children. The parameters to be matched will depend on the research question, and scientific rigour could be improved by adhering to widely accepted standards held by scientists involved in medical, behavioural, and social research (Cooper & Hedges, 1994). These standards should include: careful description of study participants (age, demographic, cognitive, academic, and behavioural characteristics); study interventions described in sufficient detail to allow for replicability, including how long the interventions lasted and how long the effects of the treatment lasted; study methods that allow judgements about how intervention fidelity was ensured; and comprehensive descriptions of outcome measures.

Alternative research designs which might yield more high-level evidence could include non-equivalent control group design (e.g. existing groups assigned to treatment or no treatment conditions, with no random assignment); one group repeated measures design (i.e. one group receives multiple treatments); multiple baseline designs (i.e. single subject or aggregated-subjects design); and multi-centre prospective quasi-experimental designs (Crombie & Davies, 1996; Moore & McCabe, 1993). These designs are better suited to measuring intervention efficacy and effectiveness. A comparison of results using a similar research design model with alternative education approaches would help to give evidence to parents and professionals of efficacy (results of the intervention applied under ideal conditions) and effectiveness (results of the intervention ‘in the real world’, where there are fewer controls) (Hall, 2003; Rhoades, 2006).

One way to compare two different education options in the future might involve setting a benchmark for developmental progress and measuring outcomes for the different options against it. This
could potentially be achieved with longitudinal controlled studies that compare the rate of speech and language development over a fixed period for children educated in different education approaches and programs with the developmental progress for children with normal hearing over the same period. This is similar to the model for studying developmental progress for speech and language skills in an AVT program reported in the initial publication of a longitudinal study (Dornan, Hickson, Murdoch, & Houston, 2007) (see Chapter 3). Here a control group of children matched for language age and other important variables was used for comparison. It will also be important in the future to include measures on a wide range of outcomes parameters, including receptive and expressive language, vocabulary, speech skills, literacy, mathematics, social functioning, self-perception and personal adjustment for children educated in different programs.

With the introduction of universal newborn hearing screening in many countries worldwide and consequently a trend towards early amplification and cochlear implantation, it is evident that children who are diagnosed and receive audiological and education intervention before the age of 6 months of age have the potential to achieve age appropriate scores in speech and language within 1 to 5 years, provided they have no other cognitive disabilities (Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). As AVT is considered an early intervention approach, and not a classroom intervention, future studies are needed to investigate speech and language progress in the early intervention years, particularly in the newborn to 2-year-old age group. Because of the intrinsic variability of this population, it will be important to establish child and family variables that might need to be controlled in order to reduce bias in the findings, and to recognise the various cultural and socio-economic factors which have potential influence on the outcomes (Eriks-Brophy, 2004). This population brings even more challenges for research. Babies’ responses are difficult to reliably assess, few standardised tools exist, and the emotional factors for new parents facing difficult decisions are a major variable. One of the critical questions for future research is “Which type of education approach allows children diagnosed with hearing loss before 6 months of age the fastest trajectory for speech and language development in order to catch up with their peers within the critical windows of time for optimal neural plasticity?” Future research investigating treatment outcomes for paediatric hearing loss must address the many challenges of research in this very young population.

In conclusion, there is evidence to suggest that significant progress can be made by individual children using AVT, some to the point at which they are functioning at age-appropriate language levels. This review has shown that, although children have the potential for substantial positive benefits, it is not
possible to conclude that there is a direct cause and effect relationship between AVT and child outcomes based on the primarily Class III and minimal Class II evidence. However, because early diagnosis through the implementation of newborn bearing screening is identifying a growing number of babies requiring early intervention, increasing the strength of evidence for outcomes of AVT is critical for future progress in the science of treatment of young children with hearing loss.
REFERENCES

Alexander Graham Bell Academy for Listening and Spoken Language (2007). Alexander Graham Bell

http://www.ncbegin.org/communication_options/comm_options_chart.shtml.


language, early reading and social emotional development. Journal of Deaf Studies and Deaf
Education, 5(2), 140-155.

Connor, C.M., Craig, H.K., Raudenbush, S.W., Heavner, K., & Zwolan, T.A. (2006). The age at which
young deaf children receive cochlear implants and their vocabulary and speech-production growth:

Service.

using cochlear implants: Oral or total communication? Journal of Speech, Language and Hearing
Research, 43, 1185-1204.

comprehensive skills of children who use cochlear implants. Journal of Speech, Language and
Hearing Research, 47(3), 509-526.

health services research. Chichester, England: John Wiley & Sons.

Comparison of language ability in children with cochlear implants placed in oral and total
communication educational settings. Annals of Otology, Rhinology and Laryngology, 109(12), 121-
123.


Tysz


CHAPTER THREE

Outcomes of an Auditory-Verbal Therapy Program for Children with Hearing Loss – A Comparative Study with a Matched Group of Children with Normal Hearing


³This chapter contains the results measured at the 9 months posttest and is an adaptation of the manuscript entitled “Outcomes of an Auditory-Verbal Therapy program for children with hearing loss - A comparative study with a matched group of children with normal hearing”, published in The Volta Review in 2007. It is inserted as accepted for publication, with the exception of formatting and wording changes to headings, tables and figures to maintain consistency throughout the thesis, and the addition of the word “Therapy” to denote “AVT” as this paper was written prior to the 2007 changes in terminology (see Chapter One, Section 1.6, p 11). In this chapter, the terms “experimental group” and “control group” have also been changed to AVT group and TH (typical hearing) group to maintain consistency throughout the thesis, and the term “typical” has been used instead of “normal” in this text.
3.1 INTRODUCTION

Hearing loss in children often causes delays in speech and language development (Dodd, McIntosh, & Woodhouse, 1998; Moeller, 2000), and the gap between chronological age and language age for children with significant loss often remains or widens over time (Geers, 2005; Miyamoto, Svirsky, & Robbins, 1997; McConkey, Robbins, Svirsky, & Iler-Kirk, 1997; Svirsky, 2000). Recent research and clinical outcomes indicate potential for spoken language development in children with hearing loss who use AVT (Goldberg & Flexer, 1993, 2001; Durieux-Smith, Eriks-Brophy, Olds, Fitzpatrick, Duquette, & Whittingham, 2001; Durieux-Smith, Olds, Eriks-Brophy, Fitzpatrick, Duquette, & Capelli, 1998; Wray, Flexer, & Guthrie, 2001). This study investigated the speech and language developmental progress of 29 children who use modern hearing technology coupled with AVT and compared their developmental progress with children with typical hearing of the same language age.

Few studies have investigated spoken language outcomes for children educated using AVT. A recent comprehensive review of research by Eriks-Brophy (2004) concluded there was only limited evidence in favour of AVT because of significant problems with research design. These problems included the manner of collection of research data (retrospective, anecdotal, questionnaire/expert opinion or student file evidence), selection criteria for participants and lack of a control group. In addition, only one study reviewed by Eriks-Brophy used standardised measures with normative data allowing comparison with children with typical hearing (Rhoades & Chisolm, 2000; Rhoades, 2001). The results of this study indicated that 12 months or more of global language progress occurred in a 12-month time frame for 40 children with moderate-to-profound hearing loss in an AVT program. The children had been in the program for one to four years. Another finding of Rhoades’ research was that, on average, a group of 14 “graduates” from the AVT program (i.e., children who had been professionally released) was able to close the gap between chronological age and language age. Although the number of children in this study was small and a control group was not included, the results do provide positive evidence for AVT (Eriks-Brophy, 2004).

Duncan (1999) and Duncan and Rochecouste (1999) have reported another study that did include some comparison to children with normal hearing. These authors compared the length and complexity of utterances produced by four- and five-year old children with hearing loss in an AVT program to peers with normal hearing. Both groups were enrolled in the same integrated setting. The authors found there
were fewer differences between the results for the two groups of five-year olds than for the two groups of four-year-olds, indicating that the children with hearing loss may have been moving toward narrowing the gap between chronological age and language age that typically is seen in children with hearing loss. Duncan (1999) also found that, for the same population, there were no significant differences between groups for the majority of conversational skills. However, these positive results have some limitations that must be considered, including matching for chronological age instead of language age, no matching for gender or socioeconomic status and small sample size (11 children).

Other evidence of positive outcomes for children from AVT programs comes from retrospective studies (Goldberg & Flexer, 1993, 2001; Durieux-Smith, Eriks-Brophy, Olds, Fitzpatrick, Duquette, & Whittingham, 2001; Durieux-Smith, Olds, Eriks-Brophy, Fitzpatrick, Duquette, & Capelli, 1998; Wray, Flexer, & Guthrie, 2001). A high percentage of children “graduating” from these programs was found to enter mainstream education and had potential for academic achievement in regular classes. Importantly, few participants in these studies received the benefits of early cochlear implantation. Several studies also report potential for literacy development for children with hearing loss educated using AVT (Robertson & Flexer, 1993; Wray et al., 2001; Wray, Flexer, & Vaccaro, 1997). Though not providing strong empirical evidence, these studies have provided professionals with the basis for description of the possible potential of AVT for parents of children with hearing loss. Several authors (Easterbrooks, O’Rourke, & Todd, 2000; Wu & Brown, 2004) have investigated the characteristics typical of children who succeeded in an AVT program and report that parental involvement and the child’s lack of other disabilities were important indicators of success.

Overall, there is some limited evidence to support positive speech and language outcomes for children with hearing loss in AVT programs. However, it is difficult to generalise the evidence for the potential of AVT in developing speech and language abilities from the existing outcomes studies because of the retrospective and anecdotal nature of the research and the inclusion of a control group in only one study (Duncan, 1999; Duncan & Rochecouste, 1999). According to the Oxford Centre for Evidence-Based Medicine (May 2001), the highest rated type of clinical evidence (Class 1 evidence) comes from research involving randomized controlled trials that include multiway sensitivity analysis with a minimum of 30 subjects each for the experimental and the control groups and with results indicating significant differences between groups and reliable narrow confidence intervals (Guyatt & Rennie, 2002).
Also, the experimental group would need to be enrolled at the same point in intervention and have similar points of diagnosis and amplification. It is impossible to obtain this type of evidence in the area of AVT outcomes research because, for ethical reasons, children cannot be randomly assigned to other levels of treatment once their parents have chosen a particular approach and because there is usually a large number of uncontrollable variables in any chosen population (Eriks-Brophy, 2004). The second highest-ranking form of evidence is the cohort study, where the performance of an experimental group is compared to a control group. We used this approach in the present study to determine, over a nine-month period, the speech and language progress of children with hearing loss who were enrolled in an AVT program compared to that of children with normal hearing.

In the present study, we made the following assumptions:

- Children with hearing loss attending an AVT program would make significant progress over a nine-month period in language development and speech production.
- The progress made by children with hearing loss in an AVT program for receptive and expressive language and speech production over a nine-month period would be the same as that for a group of children with normal hearing matched for language age, receptive vocabulary, gender and socioeconomic level.

3.2 METHOD

The present study employed a matched-group, repeated-measures design. The two groups of children were assessed on a range of speech and language measures at the start of the study (pretest) and again nine months later (posttest).

3.2.1 Matching of Groups

Pairs of children were matched at the beginning of the study on the basis of language age using the Preschool Language Scale-4 (PLS-4) (Zimmerman, Steiner, & Pond, 2002) and the Clinical Evaluation of Language Fundamentals-3 (CELF-3) (Semel, Wiig, & Secord, 1995). Had chronological age been used, as it was by Duncan (1999) and Duncan and Rochecouste (1999), the children with typical hearing would
have had a higher language level than the children with hearing loss of the same chronological age, introducing the possibility that the group of children with typical hearing might progress faster.

This study was conducted in Queensland, Australia, and, at the time, the average age for diagnosis for children with sensorineural hearing loss in Australia was over two years because newborn hearing screening programs were not yet in place (Wake, 2002). Thus, it was highly likely that if we had matched children by chronological age, the children with typical hearing would have had a significant language age advantage over the children with hearing loss. It is also possible that matching children for language age could have resulted in the children with hearing loss being significantly older than the children with typical hearing (Blamey et al., 2001), introducing the potential that they might progress faster because of their superior cognitive skills. However, it was considered that the potential cognitive ‘advantage’ afforded to the children with hearing loss who were older was likely to be offset by the delays they often experience in speech and language development.

### 3.2.2 Materials

The following standardised test measures were used in the present study:

- **Preschool Language Scale-Fourth Edition**-4 (PLS-4) (Zimmerman, Steiner, & Pond, 2002). The scoring ceiling used was five consecutive items incorrect. If a child obtained the highest possible score on the PLS-4, the CELF-3 was used.
- **Clinical Evaluation of Language Fundamentals**-3 (CELF-3) (Semel, Wiig, & Secord, 1995). Six subtests were administered only to children who achieved the top score for the PLS-4. The subtests were Sentence Structure, Word Structure, Concepts and Directions, Formulated Sentences, Word Classes and Sentence Recalling.
- **Peabody Picture Vocabulary Test**-3 (PPVT-3) (Dunn & Dunn, 1997). Because this test was developed in the United States, Australian alternatives for four items were used by the testers: “cupboard” for “closet,” “rubbish” for “garbage,” “biscuit” for “cookie,” and “jug” for “pitcher.” These substitutes had minimal effects on performance as the American equivalents are not commonly used in Australia.
- **Goldman-Fristoe Test of Articulation**-2 (GFTA-2) (Goldman & Fristoe, 2001). The “Sounds-in-Words” subtest was used.
In addition to the standardised measures, a written Parent Survey developed by the researchers was administered to parents at the time of both the pre- and the posttest. This Parent Survey was designed to determine the parent’s perspective on the developmental progress related to the listening and spoken language skills of their child with hearing loss and consisted of questions that included listening behaviour and comprehension of language, as well as information on the child’s emerging spoken language in social environments. The Parent Survey, which was intended to give qualitative information on the child’s speech and language progress, was completed by the family at home and returned.

3.2.3 Participants

Experimental Group

Twenty-nine children with a range of sensorineural hearing losses and amplified with either hearing aids or cochlear implants were recruited from five regional centres of an AVT program in Queensland, Australia. These centres adhere to the principles of AVT and offer a range of services including early intervention and cochlear implant programs. All children participating in this survey were receiving regular audiological follow-up to ensure optimal amplification as well as weekly individual therapy in which parents were guided and coached as primary language models for their child.

Diagnostic teaching principles also were employed, and children were integrated fully into mainstream education (kindergarten at age three years or preschool at age four years) as soon as it was possible, the decision being made jointly by the parents and the clinician. Potential participants included 65 children in the early intervention program whose ages fell within the criteria for candidacy, who were accessibly geographically and whose parents agreed to participate in the research. Those children included in the sample involved every child in the two- to six-year-old age group who fit the selection criteria, because no parent refused permission for their child to participate. Selection criteria were the following:

- Pure tone average of ≥40 dB hearing threshold level in the better ear for four frequencies (PTA-4) at 500 Hz; 1,000 Hz; 2,000 Hz and 4,000 Hz
- Prelingual deafness (at ≤18 months old)
- Weekly attendance in the educational program for intensive one-to-one, parent-based AVT for a minimum of six months
• Consistent wearing of hearing aid technology such as hearing aids and/or cochlear implants
• Aided hearing within the speech range or recipient of a cochlear implant
• Absence of other significant cognitive or physical disabilities reported by parents or educators
• Aged two-six at the first test session
• English-only language use by parents with their child

The characteristics of the children are summarised in Table 3.1.
Table 3.1 Characteristics of AVT group at 9 months posttest

<table>
<thead>
<tr>
<th>N</th>
<th>Gender</th>
<th>Type of Loss</th>
<th>Hearing Device</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Age (years)</td>
<td>Mean PTA-4 (better ear)</td>
<td>Mean Age at CI (months)</td>
</tr>
<tr>
<td>29</td>
<td>M 3.79 (SD 1.25)</td>
<td>74 dB (SD 23.6)</td>
<td>27 (SD 5.8)</td>
</tr>
<tr>
<td></td>
<td>F 21 8 24.6</td>
<td></td>
<td>2 20</td>
</tr>
</tbody>
</table>

Note: PTA-4 = pure tone average at 0.5, 1, 2 and 4 kHz

HA = hearing aid
CI = cochlear implant
AVT = AVT
The participants had bilateral sensorineural hearing loss ranging from moderate to profound, with a mean PTA of 76.17 dB HL (over 3 frequencies at 0.5, 1 and 2 kHz). The pure tone average at four frequencies (0.5, 1, 2 and 4 kHz) was 74 dB HL. There is no standard measure in Australia for defining hearing loss, and clinics vary between the use of three frequencies and four frequencies. Using four frequencies is considered a better reflection of average hearing loss (Davis & Wood, 1992), and information about hearing above 2,000 Hz is very important for speech perception; to omit it from the average may underestimate the degree of impairment.

In the sample, nine children had a moderate loss, seven children had a moderate-to-severe loss and 13 children had a profound loss. All children were fitted with hearing aids and commenced intervention within three months of identification of the hearing loss. All children with cochlear implants in this study had unilateral Cochlear Nucleus CI 24 implants1 and used an ACE processing strategy. The average age at implantation was 27 months. All but two cochlear implant users in the study also wore a hearing aid in the contralateral ear. Both hearing devices were balanced by an Australian Hearing audiologist according to the recommendation of Ching, Psarros, and Incerti (2003). Parents reported on a written survey (to be reported in a later study) that 93% of children wore their hearing aids and/or cochlear implants for 100% of their waking hours at the time of the initial assessment, and all wore them consistently at the time of the posttest nine months later.

All tests were performed in the best-aided condition. For children with cochlear implants, the child’s optimally functioning MAP and speech processor program, as assessed by the child’s audiologist and Auditory-Verbal therapist, was used. Both “T” levels and “C” levels for the child’s MAP were measured behaviourally and confirmed objectively where necessary. Optimal implant performance was verified by the stability of the MAP, consistent identification by the child of the seven-sound test (i.e., the Australian adaptation of Ling’s Six Sound Test, Romanik, 1990), other speech perception tests and the cochlear implant-assisted audiogram (a record of the child’s cochlear implant-aided thresholds for responses at 250 Hz; 500 Hz; 1,000 Hz; 2,000 Hz and 4,000 Hz).

1 This is the only device available in Australia.
For the children who wore hearing aids, best-aided condition was determined by the child’s audiologist and Auditory-Verbal therapist, performance of the seven-sound test, speech perception tests and the child’s aided audiogram. Although the selection criteria precluded children with other significant disabilities, the experimental group included one child who had mild cerebral palsy and two children who commenced investigation for the possibility of other disorders during the course of the study and subsequently transferred to a different type of program after the nine-month test period was completed.

Control Group

Children in this group were recruited by families and staff of the AVT program. Selection criteria were the following:

- Hearing threshold levels within the range of 0 to 20 dB at 500 Hz; 1,000 Hz; 2,000 Hz and 4,000 Hz for both ears
- No delay in phonetic development as assessed using the GFTA-2 (Australian norms for articulation [Kilminster & Laird, 1978] were used, and results within one standard deviation of the mean for age were required for inclusion.)
- Absence of significant cognitive or physical disabilities (as evidenced by case history or parent report)
- English-only language use by parents with their child

When matching the TH group with the AVT group, it was difficult to achieve a complete match for each individual child for both the total language score (PLS-4 or CELF-3) and the receptive vocabulary score (PPVT-3), as the range of total language and receptive vocabulary scores was wide. However, both groups of children were matched initially for total language scores and then for receptive language. Sixty-four children with typical hearing initially were tested to ensure that matching of children with the AVT group participants was possible. The 29 children finally selected for the TH group were matched with the AVT group for total language age within three months above or below their scores on the PLS-4 (Zimmerman et al., 2002) or the CELF-3 (Semel et al., 1995). They also were matched within three months above or below their scores for receptive vocabulary on the PPVT-3 (Dunn & Dunn, 1997), gender and head of the household education level. All except one parent in both groups had undertaken education beyond high school, suggesting a generally high socioeconomic level in both groups. The mean age of the control group children was 2.97 years (range 14-85 months, SD = 13 months).
3.3 PROCEDURE

Clearance for this project was sought from the medical and ethical committee of the AVT program and was then referred to the program board of directors, who approved the project. Ethical clearance also was obtained from the School of Health and Rehabilitation Sciences Research and Postgraduate Studies Committee, University of Queensland, Brisbane, Australia. After consent was obtained from the parents for each participant, arrangements were made to conduct the assessments. Assessments of children in the AVT group took place at the child’s program centre. For the TH group, testing was performed either at the centre, in a quiet room at the child’s education setting or at the child’s home.

Speech and language testing was performed by experienced, qualified speech-language pathologists. An audiologist performed all audiological assessments. Because of geographic constraints, the most convenient and available qualified staff performed the testing and, frequently, different testers assessed the children pre- and posttest. Tester reliability was not examined in the study; however, all tests were administered according to the standardised instructions in the test manuals. The language and speech tests were administered over one session if possible; however, several children required two sessions because of age or attentional constraints. Children were given rest breaks between assessments, and the session was discontinued if a child showed evidence of fatigue or distress. The children’s responses to the GFTA-2 were not transcribed and scored at a later date but, instead, were judged to be correct or incorrect at the time of testing.

The order of presentation of the standardised tests used is summarised in Table 3.2.
Table 3.2 Order of presentation for standardised assessments

<table>
<thead>
<tr>
<th>Group</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td></td>
</tr>
<tr>
<td>AVT Group</td>
<td>PLS-4 or CELF-3</td>
</tr>
<tr>
<td></td>
<td>PPVT-3</td>
</tr>
<tr>
<td></td>
<td>GFTA-2</td>
</tr>
<tr>
<td>TH Group</td>
<td>Tests Used for Screening Purposes:</td>
</tr>
<tr>
<td></td>
<td>Pure Tone Audiometry</td>
</tr>
<tr>
<td></td>
<td>GFTA-2</td>
</tr>
<tr>
<td></td>
<td>PLS-4 or CELF-3</td>
</tr>
<tr>
<td></td>
<td>PPVT-3</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
</tr>
<tr>
<td>Both Groups</td>
<td>PLS-4 or CELF-3</td>
</tr>
<tr>
<td></td>
<td>PPVT-3</td>
</tr>
<tr>
<td></td>
<td>GFTA-2</td>
</tr>
</tbody>
</table>

The order of testing for the control group was different from the experimental group to (1) account first for screening and (2) establish a match with a child in the experimental group before the child was tested unnecessarily. The mean time between pretests and posttests was 9.66 months for the experimental group and 9.40 months for the control group, with the time difference being largely due to geographical access to the children with hearing loss. A Welch two-sample $t$ test indicated that there was no significant difference between the pre- and posttest intervals for the two groups ($t = 1.095, df = 49.24, p = 0.279$).

3.4 RESULTS

In the first instance, a preliminary analysis was carried out to ensure the validity of matching of participant groups at the pretest; that is, the matching of language age and receptive vocabulary as indicated by total language age on the PLS-4 or CELF-3 and PPVT-3 results, respectively. The experimental group’s PLS-4/CELF-3 mean age equivalent was 3.47 (SD = 1.27), and the mean for the control group was 3.39 (SD = 1.31). Between-group $t$-tests showed no significant difference between
these values ($t = 0.229, df = 56, p = 0.820$). Similarly, there was no significant difference between groups for the mean vocabulary age equivalents on the PPVT-3 ($t = 0.209, df = 56, p = 0.836$). The mean age equivalent for the experimental group on the PPVT-3 was 2.65 ($SD = 1.25$), and the mean for the control group was 2.72 ($SD = 1.27$).

It is significant to note that 65.5% of the AVT group participating in this study ($n = 19$) had scores that were within the age-appropriate range for auditory comprehension on the PLS-4 at the time of the pretest. By the time of posttest nine months later, 69% ($n = 20$) were in the age-appropriate range. Similarly, for oral expression on the PLS-4, 55% ($n = 16$) of children were within the age-appropriate range at pretest and 62% ($n = 18$) fell into this range at posttest. For total language scores on the PLS-4 or CELF-3, 58.6% ($n = 17$) of children were within the age-appropriate range at pretest and 65.5% ($n = 19$) of children were within range at posttest. Also at the posttest, no children scored less or equal to their original scores at the pretest. In addition, two children in the AVT group had scores that exceeded one standard deviation above the mean both at pre- and posttest (one child on the CELF-3 and one on the PLS-4). This result placed 65.5% ($n = 19$) of children in the typical range or above for their total language age equivalent at the time of the pretest and 72.4% ($n = 21$) at posttest.

Table 3.3 summarises the changes in age-equivalent scores on all measures obtained at pre- and posttest for both groups over the nine-month test period, as well as the results of the statistical analyses.
Table 3.3 Mean age equivalents (in years), standard deviations, $t$ and $p$ values for auditory comprehension, oral expression, total language, receptive vocabulary, and speech for the 29 children in the AVT and TH groups at pretest and at 9 months posttest

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Statistical Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Auditory Comprehension (PLS-4/CELF-3)</td>
<td>AVT</td>
<td>3.49</td>
<td>1.02</td>
<td>4.32</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>3.27</td>
<td>1.02</td>
<td>4.13</td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral Expression (PLS-4/CELF-3)</td>
<td>AVT</td>
<td>3.21</td>
<td>0.97</td>
<td>3.95</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>3.20</td>
<td>1.18</td>
<td>4.03</td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Language (PLS-4/CELF-3)</td>
<td>AVT</td>
<td>3.47</td>
<td>1.27</td>
<td>4.33</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>3.39</td>
<td>1.31</td>
<td>4.20</td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPVT-3</td>
<td>AVT</td>
<td>2.65</td>
<td>1.25</td>
<td>3.80</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>2.72</td>
<td>1.27</td>
<td>3.89</td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GFTA-2</td>
<td>AVT</td>
<td>2.88</td>
<td>1.30</td>
<td>3.60</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>3.79</td>
<td>1.27</td>
<td>4.60</td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: $^a$54df  $^b$56df  $^c$50df ; * = Acceptable level of significance is $\leq$ 0.05

Mixed-model analysis, considered to be the most appropriate method of analysing longitudinal data with independent observations (Brown & Prescott, 1999) was performed to check the differences between age equivalents for both groups and to investigate gain over time for both groups. Residual diagnostic plots (including Q-Q plots) were undertaken to check the assumption of normality of the residuals,
necessary for this analysis. Box plots of the residuals for each of the groups indicated that the homogeneity of variance assumption was not violated.

For the PLS-4/CELF-3 total language scores, no significant interaction was found between the groups, and a significant time effect was seen between pre- and posttests for both groups ($F_1, 56 = 28.30; p < 0.001$). The time effect is consistent, with both groups making significant progress from pre- to posttest, and the lack of interaction is consistent with there being no difference between the rate of increase in scores for both groups. The same pattern of results was found for the auditory comprehension scores ($F_1, 56 = 176.87; p < 0.001$), oral expression scores ($F_1, 56 = 126.36; p < 0.001$), and the PPVT-3 scores ($F_1, 56 = 119.87; p < 0.001$). Similar calculations were performed for the GFTA-2, and, again, there was no interaction between groups; however, the time effect was significant. There was a difference between groups on this measure at pretest, with the TH group having higher mean scores at the initial test session ($F_1, 56 = 77.06; p < 0.001$).

Table 3.4 outlines the mean change in scores for both groups over the nine-month test period.

**Table 3.4** Summary of age equivalent gains (in months) for both groups over nine-month test period

<table>
<thead>
<tr>
<th>Test</th>
<th>AVT Group</th>
<th>TH Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Months Gain</td>
<td>Months Gain</td>
</tr>
<tr>
<td>Auditory Comprehension (PLS-4/CELF-3)</td>
<td>9.96</td>
<td>9.72</td>
</tr>
<tr>
<td>Oral Expression (PLS-4/CELF-3)</td>
<td>8.88</td>
<td>10.32</td>
</tr>
<tr>
<td>Total Language (PLS-4/CELF-3)</td>
<td>10.32</td>
<td>9.96</td>
</tr>
<tr>
<td>PPVT-3</td>
<td>13.80</td>
<td>14.04</td>
</tr>
<tr>
<td>GFTA-2</td>
<td>8.76</td>
<td>9.72</td>
</tr>
</tbody>
</table>

The data show that the average gain was nine months or greater on all measures for the TH group and on three of the measures for the AVT group (auditory comprehension, total language and PPVT-3).
3.5 DISCUSSION

This study examined the speech and language developmental progress of children with hearing loss educated using AVT as compared to that of a control group of children with typical hearing. The data was collected using standardised assessments, and the TH group matched for language age, receptive vocabulary, gender, and head of household education level was included. Statistical analysis revealed that both groups made significant progress and that there was no significant difference between the progress made by the two groups on language and receptive vocabulary scores. The speech production results indicated a lower score at the start of the study for the children with hearing loss compared to the children with typical hearing, but the developmental progress of both groups was the same.

The results support the hypotheses that children in an AVT program would make significant progress in language development and speech production over a nine-month period and that this progress would be the same as for the TH group. The mean rate of progress of the AVT group ranged from 8.76 months on the GFTA-2 to 13.80 months on the PPVT-3. These findings are similar to reports by Rhoades and Chisolm (2000) and Rhoades (2001) of children in an AVT program. Comparisons with other rate of development studies are problematic because of the inherent heterogeneity of the population.

In addition, advances in hearing technology and cochlear implant candidacy are rapidly changing the arena of research outcomes for children with hearing loss (Geers, 2005), making it even more difficult to compare this study with earlier studies where children used less sophisticated technology. A recent study investigating development rate of language skills carried out on Australian children (Blamey et al., 2001) is the most comparable. The authors examined the rate of change in language development for a group of 40 children using hearing aids (mean PTA of 78 dB HL) and a group of 47 children with cochlear implants (mean PTA of 106 dB HL). Test measures were the PLS-4/CELF-3 and the PPVT-3. All children were enrolled in oral communication programs. The authors found that the children with cochlear implants were developing language at one-half to two-thirds the rate reported for children with typical hearing, a rate that was the same as for the aided children with a severe loss participating in the study.

The current study included 15 children with cochlear implants and 14 with hearing aids; overall, the developmental progress found was superior to that reported by Blamey et al. (2001). A possible reason
for this finding is the different educational approaches in which the children were engaged. AVT involves parents as the child’s natural language teachers, sessions that are always individual and an emphasis on listening over vision (Auditory-Verbal International, Inc., 1993). This approach is compared to an oral communication approach, in which parents are not necessarily the primary language teachers, sessions can be held with individuals or groups and the amount of emphasis on vision versus listening varies according to program. For example, the Council for Exceptional Children (Easterbrooks, 1997) reported that the auditory/oral philosophy may incorporate visual methods of teaching. Another group reports that an auditory/oral program stresses the use of speech reading and natural gestures to aid the child’s communication (Beginnings, 2005).

The majority of the AVT group (72.4%) had total language scores that fell in the age-appropriate range at the posttest. We acknowledge that, as Young and Killen (2002) note, this result does not infer that the children’s spoken communication skills are the same as for children with typical hearing. Rather, these scores give an indication of level of functioning on one particular scale. These results are in agreement with other studies on AVT (Durieux-Smith et al., 1998, 2001), in which children who had graduated from an AVT program had communication skills that were age appropriate. The results are in marked contrast to those of Geers, Nicholas, and Sedey (2003) who reported that 30% of a group of 181 children with hearing loss scored at an age-appropriate level for receptive language and 47% were within the normal range for expressive language. All children in that study had received cochlear implants, and 89 participated in a Total Communication program while 92 used oral communication. However, for the studies compared, differences in variables (such as age of identification, age at implantation, tests used and testing methods employed) make direct comparisons between the outcomes of these studies difficult to interpret.

It is noted that both AVT group and TH group children in the present study exhibited significantly higher PPVT-3 scores at pre- and posttest than the general population of children with typical hearing on which the test was standardised. A possible reason for this high level of receptive vocabulary in both groups of children is the relatively high socioeconomic status of the parents (Hart & Risley, 1995; Hoff-Ginsberg, 1991). All but one parent in each group had undertaken education beyond high school. Nevertheless, the results for the children with hearing loss are promising and contrast sharply with previous studies that have reported PPVT-3 scores for children with hearing loss that are significantly lower than those of the population with typical hearing (e.g., Young & Killen, 2002; Dodd et al., 1998).
One of the desired outcomes of AVT is a high level of family involvement and increased child-directed speech (Auditory-Verbal International, Inc., 1993). In a study by Moeller (2000), positive language outcomes in children with hearing loss have been correlated with high levels of family involvement, and Hart and Risley (1995) have shown that increased child-directed speech is associated with larger vocabularies in children and faster vocabulary growth over time.

Yoshinago-Itano, Sedey, Coulter, and Mehl (1998) found that children with hearing loss who are identified early and who receive intervention before age six months have better language skills than those children identified later. It is important to note that children in the current study did not, as a group, have the benefits of newborn hearing screening and were identified relatively late, at a mean of 24.6 months of age. As participants in an AVT program, however, the children with hearing loss did receive early optimal audiological management, consistently used their hearing devices and were all users of spoken communication.

Another feature of the participants in this study was that most of the children were male. The results may have been adversely affected by this large number of male children, as females are known to have a verbal advantage over males (Fenson, Pethick, Renda, Cox, Dale, & Reznick, 2000). The advantage for females also has been noted by Easterbrooks and O’Rourke (2001) when studying children in an AVT program.

This study addresses some of the methodological problems in existing research noted by Eriks-Brophy (2004). Several communication domains were examined, namely language reception and expression, receptive vocabulary and speech skills. The limitations of the study were that it was conducted on a sample size of 29 children over a short period of time (i.e., nine months), and the participants had the variability typical of any group of children with hearing loss. As stated earlier, the small sample size in this study is acknowledged as a limitation, and it is not appropriate to generalize the results to the population at large.

The authors plan to extend this study longitudinally and to examine additional domains such as literacy, numeracy, social and psychosocial functioning. Future research is also needed to investigate the progress of children in other AVT programs and those using alternative educational options.
3.6 REFERENCES


CHAPTER FOUR


(This chapter contains the results measured at the (21 months) posttest and is an adaptation of the manuscript entitled “Longitudinal study of speech perception, speech and language for children with hearing loss in an Auditory-Verbal Therapy program”, published in The Volta Review in 2009. It is inserted as accepted for publication, with the exception of formatting and wording changes to headings, tables and figures to maintain consistency throughout the thesis.)
4.1 INTRODUCTION

This research is part of a longitudinal study examining the outcomes for children with hearing loss who are enrolled in an Auditory-Verbal Therapy (AVT) program and whose parents are seeking a listening and spoken language outcome. Between 2 and 3 children per 1,000 are born with permanent sensorineural hearing loss > 35 dB HL per year, the most common congenital disorder that can be detected in the newborn period (Fortnum, Summerfield, Marshall, Davis, & Bamford, 2001; Joint Committee on Infant Hearing, 2007; Uus & Bamford, 2006). This incidence is likely to be higher in developing countries (Olusanya, Ruben, & Parving, 2006). Untreated hearing loss in children has a significant impact on auditory brain development (Sharma, Dorman, & Kral, 2005), with serious lifetime consequences for speech, language, literacy, academic achievement, and social/emotional development (Bat-Chava, Martin, & Kosciw, 2005; Blamey et al., 2001; Nunes & Moreno, 2002; Sininger, 1999; Traxler, 2000). Hearing loss also significantly impacts the family and community (Olusanya et al., 2006). Treatment of childhood hearing loss has made many advances in the last decade, and clinical evidence shows that life-changing improvements in outcomes for children with hearing loss are now possible with the combination of new technology and intervention techniques (Geers, 2004). Rigorous research is needed to develop an evidence base that will inform professionals, decision makers, and funding bodies about the effectiveness of intervention strategies for children with hearing loss whose parents seek a spoken language outcome.

Early diagnosis and immediate audiological and educational intervention, preferably by 6 months of age, are vital in order to capitalize on the optimal developmental periods of the auditory brain (Joint Committee on Infant Hearing, 2007; Sharma et al., 2005; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). Modern diagnostic technology, such as frequency-specific electrophysiological measurements (Cone-Wesson, Dowell, Tomlin, Rance, & Ming, 2002), and hearing technology, such as cochlear implants and digital hearing aids, are offering new opportunities for children with significant hearing loss to acquire listening and spoken language (Geers, 2004). Fitting of amplification accompanied by immediate and appropriate educational intervention must quickly follow diagnosis if the new opportunities are to lead to an improvement in spoken language outcomes (Nicholas & Geers, 2007). As technology for diagnosis and audiological intervention for hearing loss continues to advance, better speech and language outcomes have become possibilities for children with hearing loss. These developments have created more demand for listening and spoken language outcomes (Rhoades, 2006).
However, there is a lack of high-level research (as defined by the “Levels of Evidence” of the Oxford Centre for Evidence Based Medicine, 2001) on any of the educational approaches available today (Sussman et al., 2004). There is a great need to conduct research focusing on the measurement of outcomes as evidence for “best practices” in the treatment of various populations of children with hearing loss. Prior to the use of cochlear implants, rate of language progress for children with profound hearing loss wearing hearing aids was reported as half a year of progress in a 1-year time span (Boothroyd, Geers, & Moog, 1991). With new hearing technology, many authors consider that progress of children with hearing loss may be appropriately compared to that of children with typical hearing (Geers, 2005). This study is part of a longitudinal research project that aims to contribute to research evidence by comparing the developmental progress of speech and language skills for children in an AVT program to that of children with typical hearing.

AVT is an early intervention education option that facilitates optimal acquisition of spoken language through listening by young children with hearing loss. It promotes early diagnosis, one-on-one therapy, and state-of-the-art audiologic management and technology. Parents and caregivers actively participate in therapy. Through guidance, coaching, and demonstration, parents become the primary facilitators of their child's spoken language development. Ultimately, parents and caregivers gain confidence that their child can have access to a full range of academic, social, and occupational choices throughout life (AG Bell Academy for Listening and Spoken Language, 2007).

A number of authors have published reviews of research on AVT outcomes (see Dornan, Hickson, Murdoch, & Houston, 2008; Eriks-Brophy, 2004; Rhoades, 2006). Eriks-Brophy (2004) cited significant problems related to research design, including the fact that most studies were retrospective and were without control groups. She concluded that the research overall was sparse and incomplete, and provided only limited evidence in favor of AVT, a view that was supported by Rhoades (2006) and Dornan et al. (2008). The research design problems highlighted by these authors mean that comparison between studies on outcomes of AVT, or indeed between studies on any of the other communication options, is extremely difficult. However, several large retrospective studies (e.g., Goldberg & Flexer, 2001; Durieux-Smith et al., 1998), and a few prospective ones (e.g., Duncan, 1999; Duncan & Rochecouste, 1999; Rhoades, 2001; Rhoades & Chisolm, 2000), have provided limited evidence for the potential of AVT for some children with hearing loss. The latter two papers on the same population reported that the children had progressed at the same rate as children with typical hearing, and entered
school with age-appropriate language skills. However, those studies did not actually have a control group of children with typical hearing, and such a comparison would be appropriate and informative.

In an earlier stage of our own research (Dornan, Hickson, Murdoch, & Houston, 2007), the speech and language developmental progress of children with hearing loss using an AVT approach was compared over a 9-month period to that of a matched group of children with typical hearing. The original group of children with hearing loss consisted of 29 children ages 2-6 years with a mean Pure-Tone Average (PTA) in the better ear of 76.17 dB HL at 0.5, 1 and 2 kHz. The 29 children in the control group were matched with the children in the AVT program for language age and receptive vocabulary at the start of the study, and for gender and parental education level. A battery of standardized speech and language tests was administered to all children at the start of the study, and again 9 months later. Results showed that both groups improved over time and that there was no significant difference in progress between the two groups.

In this paper, we report on the second stage of this longitudinal study with testing occurring at 21 months after the initial assessments. The aims of the research were to investigate the developmental progress of speech and language skills for 25 pairs of the same children who remained in the study for 21 months. Developmental progress for speech and language was again compared between the two groups. This study also aimed to extend the original study by including additional measures of speech perception and speech production skills for consonants in spontaneous discourse for the children with hearing loss.

4.2 METHOD

The study employed a matched group, repeated-measures design in which children with hearing loss in an AVT program were individually matched with a comparison group of children with typical hearing. The rate of change for various language and speech variables was compared for the AVT group (AVT group) and the typical hearing group (TH group). Participants in both groups were assessed at the start of the study (pretest) and at the 21-month point (posttest) using an assessment battery. The children in the AVT group received additional assessments of speech perception and speech production in discourse.
4.2.1 Participants

AVT Group

At the 21-month stage of the study, 25 members of the original AVT group remained in the longitudinal study, and only the original child matched from the TH group was used for comparison (n = 25). The 4 original AVT group children who withdrew from the study included 2 children who had commenced investigation for other additional disorders during the first 9 months of the study and were subsequently transferred to a different type of educational program, and 2 who moved to a different area and were unavailable. The remaining 25 AVT group children had a range of sensorineural hearing losses, used hearing aids and/or cochlear implants to access sound, and were assessed on a battery of speech perception, speech, and language tests. These children attended one of four regional centers of an AVT program in Queensland, Australia, which offers a range of services including audiological, early intervention, and cochlear implant services. The AVT program adheres to the Principles of Listening and Spoken Language – Auditory-Verbal Therapy (endorsed by the AG Bell Academy for Listening and Spoken Language, 2007). All children in the AVT group were receiving regular audiologic follow-up to ensure optimal amplification, and attending weekly individual therapy sessions in which parents were guided and coached to be the primary language models for their child. Diagnostic teaching principles were also employed and children were fully integrated into mainstream education at the earliest possible age. Potential participants at the start of the study included all the program’s 75 children (2 months to 6 years of age) who were in the early intervention program, satisfied the selection criteria, were geographically accessible, and whose parents agreed to participate in the research. Selection criteria were as follows:

- Pure-Tone Average (PTA) at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz of ≥ 40 dB hearing threshold levels in the better ear.
- Prelingually deafened (at ≤ 18 months old).
- Attended the educational program weekly for intensive one-to-one, parent-based AVT for a minimum of 6 months.
- Wore consistent hearing amplification (hearing aids and/or cochlear implants).
- Had aided hearing within the speech range or had received a cochlear implant.
- No other significant cognitive or physical disabilities reported by parents or educators.
- Ages 2-6 years at the pretest session.
- Both parents spoke only English to the child.
Although the selection criteria precluded children with other significant disabilities, the group included one child who had mild cerebral palsy. The characteristics of the AVT group are summarized in Table 4.1. Their mean age at pretest was 3 years, 9 months, and at posttest was 5 years, 8 months (SD = 15 months). The 25 participants had bilateral sensorineural hearing loss ranging from moderate to profound, with a mean PTA of 79.37 dB HL. All children were fitted with hearing aids and commenced intervention within 3 months of diagnosis of the hearing loss. Three of the children had been diagnosed and commenced intervention before the critical age of 6 months identified by Yoshinaga-Itano and others (1998). These 3 children had a profound bilateral sensorineural loss, and subsequently received a cochlear implant before 19 months of age. All children with implants in this study had received unilateral Cochlear Nucleus CI 24 implants and used an Advanced Combined Encoder (ACE) processing strategy. The median age at implantation was 23.04 months (mean = 27.54 months, SD = 15.24). This relatively late mean time of implantation was due to the fact that 2 children received a unilateral cochlear implant around 4 years of age during the first 9 months of the study. All but 2 children in the study who use cochlear implants also wore a hearing aid in the contralateral ear. Both hearing devices were balanced by an audiologist according to the recommendation of Ching, Psarros, and Incerti (2003). All children wore their hearing aids consistently at the first follow-up (9 months after pretest), and continued to do so at the posttest (21 months after pretest).
Table 4.1 Characteristics of AVT group and TH group at 21 months posttest

<table>
<thead>
<tr>
<th></th>
<th>AVT Group</th>
<th>TH Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of children</strong></td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td><strong>Mean age in years (SD)</strong></td>
<td>5.7 (1.25)</td>
<td>4.79 (1.23)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td><strong>Age at identification in months</strong></td>
<td>24.6</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Mean PTA better ear (SD)</strong></td>
<td>79.37 (22.79)</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Onset of loss</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congenital</td>
<td>23</td>
<td>n/a</td>
</tr>
<tr>
<td>Prelingual</td>
<td>2</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Age at CI in months (SD)</strong></td>
<td>27 (5.8)</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Time spent in AVT program in months (SD)</strong></td>
<td>41 (16.34)</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Hearing Device:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of children with bilateral HA’s</td>
<td>10</td>
<td>n/a</td>
</tr>
<tr>
<td>Number of children with unilateral HA</td>
<td>1</td>
<td>n/a</td>
</tr>
<tr>
<td>Number of children with HA in one ear and CI in the other</td>
<td>12</td>
<td>n/a</td>
</tr>
<tr>
<td>Number of children with one CI only</td>
<td>2</td>
<td>n/a</td>
</tr>
</tbody>
</table>

HA = hearing aid  
CI = cochlear implant

**Typical Hearing Group**

Children in this group were recruited by families and staff of the AVT program. Selection criteria were as follows:

- Unaided hearing threshold levels within the range of 0 to 20 dB at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz for both ears.
- No delay in phonetic development as assessed using the Goldman-Fristoe Test of Articulation-2 (GFTA-2) (Goldman & Fristoe, 2001). Australian norms for articulation (Kilminster & Laird,
1978) were used and results within 1 standard deviation (SD) of the mean for age were required for inclusion.

- No significant cognitive or physical disabilities (as evidenced by case history or parent report).
- Both parents spoke only English to the child.

The characteristics of the control group are summarized in Table 4.1. Hearing level expressed as PTA is not reported for this group. Sixty-four children with typical hearing were initially tested to ensure appropriate matching of children in the two groups. For the longitudinal study, the 25 children with typical hearing selected for the TH group were individually matched with children in the AVT group for total language age on the Preschool Language Scale (PLS-4) or the Clinical Evaluation of Language Fundamentals (CELF-3) (+ 3 months), for receptive vocabulary on the Peabody Picture Vocabulary Test (PPVT-3) (+ 3 months), for gender, and for socioeconomic level as assessed by education level of the head of the household. The mean age at pretest was 2 years 11 months and at posttest was 4 years 9 months (SD = 14.75 months). This meant that the AVT group were 10 months older than the TH group. Had chronological age been used for matching (instead of language age), as was done in the study reported by Duncan (1999) and Duncan and Rochecouste (1999), the children with typical hearing generally would have had a higher language level than the children with hearing loss of the same chronological age (Blamey et al., 2001), introducing the possibility that the children in the TH group might progress faster.

In addition, the study was conducted in Queensland, Australia. At the time, the average age for diagnosis of a sensorineural hearing loss in Australia was over 2 years because newborn hearing screening programs were not yet in place (Wake, 2002). Thus, it was highly likely that if the children were matched by chronological age, participants in the TH group would have had a significant language age advantage over participants in the AVT group. It is also possible that matching children for language age could have resulted in the children with hearing loss being significantly older than the children with typical hearing (Blamey et al., 2001), introducing the potential that they may progress faster because of their advanced cognitive skills. However, it was considered that the potential cognitive “advantage” afforded to the children with hearing loss who were older was likely to be offset by the delays they may experience in speech and language development.
When matching the control group with the AVT group, it was difficult to achieve a complete match for each individual child for both the total language score (PLS-4 or CELF-3) and the receptive vocabulary score (PPVT-3) as the range of total language and receptive vocabulary scores was wide. However, both groups of children were initially matched for total language scores, and then for receptive vocabulary. Deciding how to define socioeconomic level for matching purposes was difficult because there are many different perspectives and a number of different possible measures (Kumar et al., 2008). Some factors that might have been measured include family income, education level of the parents, and parental occupation (Marschark & Spencer, 2003). However, it was thought that questions about family income might deter parents from long-term commitment to the longitudinal study before it had commenced. Consequently, the occupations of both groups were placed in categories according to those developed by Jones (2003) for parents in education programs, as occupation category has been found to impact the vocabulary learning of a child with hearing loss (Hart & Risley, 1995) (see Table 4.2).

<table>
<thead>
<tr>
<th>Occupation</th>
<th>AVT Group</th>
<th>TH Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>43%</td>
<td>15%</td>
</tr>
<tr>
<td>Professional</td>
<td>14%</td>
<td>65%</td>
</tr>
<tr>
<td>Technical/Trade</td>
<td>29%</td>
<td>5%</td>
</tr>
<tr>
<td>Community/Personnel</td>
<td>7%</td>
<td>0%</td>
</tr>
<tr>
<td>Clerical/Administrative</td>
<td>7%</td>
<td>10%</td>
</tr>
<tr>
<td>Sales</td>
<td>0%</td>
<td>5%</td>
</tr>
</tbody>
</table>

The heads of the household were then matched for highest education level reached (the father in the case of two-parent families or the mother/income-earning partner in the case of other family models). All except one parent in both groups had undertaken education beyond high school, suggesting a moderate to high socioeconomic level in both groups. Earlier studies have found that parents of children in AVT programs are likely to come from moderate to high socioeconomic levels
(Dornan et al., 2007; Easterbrooks, O’Rourke, & Todd, 2000; Rhoades & Chisolm, 2000). This is acknowledged as a limitation of the study.

A preliminary analysis was carried out to ensure the validity of matching participant groups at the pretest; that is, the matching of language age and receptive vocabulary as indicated by total language age on the PLS-4 or CELF-3, and the PPVT-3 results, respectively. The AVT group’s PLS-4/CELF-3 mean age equivalent was 3.58 years (SD = 1.39), and the mean for the TH group was 3.48 years (SD = 1.38). Between-group t tests showed no significant difference between these values ($t = 0.260, p = 0.796$). Similarly, there was no significant difference between groups for the mean vocabulary age equivalents on the PPVT-3 ($t = 2.80, p = 0.906$). The mean age equivalent on the PPVT-3 for the AVT group was 2.8 years (SD = 1.29) and the mean for the TH group was 2.84 years (SD = 1.31).

### 4.3 MATERIALS

All speech perception and speech and language assessments are summarized in Table 4.3. A battery of speech perception tests was used to measure the level of understanding of speech and to ensure that the children in the AVT group were receiving sound optimally. Because of variation in the level of speech perception ability and the different ages of the AVT group, a battery of speech perception assessments was necessary to best assess the children’s performance. The tests are shown in Table 4.3 in ascending order of difficulty. An audiologist administered the tests in this order according to the age and stage of listening of the child both at pretest and posttest. All speech perception tests were administered in a soundproof booth that met Australian Standards AS1269. Live-voice tests were presented in the audiologist’s own voice, and recorded-voice tests were presented by using a recording at 65 dBA in a quiet space.
### Table 4.3 Battery of assessments

<table>
<thead>
<tr>
<th>Test</th>
<th>Description of Test</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speech Perception</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLOTT (Plant, 1984)</td>
<td>The child is asked to repeat back 22 phonemes that represent the full range of speech frequencies; presented via live voice</td>
<td>If the child repeats the phoneme correctly, he or she scores 1 point for both detection and imitation. An incorrect response is scored with a detection point only, and no response receives no points. A percentage score is calculated for both detection and imitation.</td>
</tr>
<tr>
<td>Manchester Junior Words/PBK (Phonetically Balanced List for Kids) Words (Watson, 1957)</td>
<td>The child is asked to repeat back 10 simple monosyllabic words; presented via live voice.</td>
<td>The responses are scored by whole words correct and by phonemes correct. For example, if the target word is school and the child responds soon, he or she would score 2 out of a possible 4 for Phoneme Score and 0 out of 1 for Word Score. If the child responds school, he or she would score 4 out of 4 for Phoneme Score and 1 out of 1 for Word Score. A percentage score for phonemes correct and for whole words correct is obtained.</td>
</tr>
<tr>
<td>Test</td>
<td>Description of Test</td>
<td>Scoring</td>
</tr>
<tr>
<td>------</td>
<td>---------------------</td>
<td>---------</td>
</tr>
<tr>
<td>CNC (Consonant-Nucleus-Consonant) Words (Peterson &amp; Lehiste, 1962)</td>
<td>The child is asked to repeat back 25 monosyllabic words either presented via live voice or recorded voice at 65 dBA. The pediatric list used at this AVT program is half the adult list of 50 words.</td>
<td>The responses are phonetically transcribed and scored by whole words correct and by phonemes correct. Percentage scores for whole words, vowels, consonants, and phonemes are obtained.</td>
</tr>
<tr>
<td>BKB (Bench, Kowal, and Bamford) Sentences (Bench &amp; Bamford, 1979)</td>
<td>The child is asked to repeat back 16 sentences that are presented via live voice or recorded voice at 65 dBA.</td>
<td>Scoring is by key words correct. For example, “The clown had a funny face” has 3 key words (maximum points for the sentence is 3). If the child repeats “The clown was funny,” he or she would score 2 points. Final score is percentage key words correct.</td>
</tr>
</tbody>
</table>

**Language**

<table>
<thead>
<tr>
<th>Language</th>
<th>Description</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preschool Language Scale-Fourth Edition (PLS-4) (Zimmerman, Steiner, &amp; Pond, 2002)</td>
<td>Measures young child’s receptive and expressive language from birth to 6 years 11 months.</td>
<td>The scoring ceiling used was five consecutive items incorrect. Child’s score is expressed as an age equivalent.</td>
</tr>
<tr>
<td>Test</td>
<td>Description of Test</td>
<td>Scoring</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Clinical Evaluation of Language Fundamentals (CELF-3) (Semel, Wiig, &amp; Secord, 1995)</td>
<td>Measures child’s receptive and expressive language from 21 months to 6 years.</td>
<td>If a child scored the highest possible score on the PLS-4, the CELF-3 was administered. The child’s score is expressed as an age equivalent.</td>
</tr>
<tr>
<td></td>
<td>Six subtests were administered only to children who achieved higher than the top score for the PLS-4. Subtests were Sentence Structure, Word Structure, Concepts and Directions, Formulated Sentences, Word Classes, and Sentence Recalling.</td>
<td></td>
</tr>
<tr>
<td>Receptive Vocabulary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peabody Picture Vocabulary Test (PPVT-3) (Dunn &amp; Dunn, 1997)</td>
<td>Measures child’s receptive vocabulary. Because this test was developed in the United States, four Australian alternatives for items were used by the testers: <em>cupboard</em> for <em>closet</em>, <em>rubbish</em> for <em>garbage</em>, <em>biscuit</em> for <em>cookie</em>, and <em>jug</em> for <em>pitcher</em>.</td>
<td>Child’s score is expressed as an age equivalent.</td>
</tr>
</tbody>
</table>
### Speech

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goldman-Fristoe Test of Articulation-2 (GFTA-2) (Goldman &amp; Fristoe, 2001)</td>
<td>Assesses articulation of consonants and was administered to participants in both AVT and TH groups.</td>
<td>Child’s score is expressed as an age equivalent.</td>
</tr>
<tr>
<td>CASALA (Computer Aided Speech and Language Analysis) (Serry, Blamey, Spain, &amp; James, 1997)</td>
<td>This assessed articulation of consonants from a videotaped sample of spontaneous speech for children in the AVT group only. It was designed to transcribe and analyze phonetic aspects of speech samples. Broad transcription was chosen for reliability (Bow, Blamey, Paatsch, &amp; Sarant, 2002; Shriberg &amp; Lof, 1991).</td>
<td>For a consonant to be scored as an attempted production, two well-formed examples of phonemes are required to be present in a sample, regardless of whether the produced phoneme had an identifiable target. For a consonant to be scored as correctly produced, it had to be produced correctly at least twice within a sample, with a minimum of 50% of the phoneme targets to be correctly produced. Score is measured as percent consonants attempted and percent correct consonants.</td>
</tr>
</tbody>
</table>
4.4 PROCEDURE

Clearance for this project was sought from the ethics committee of the AVT program and was then referred to the program board of directors, which approved the project. Ethical clearance was also obtained from the Behavioural and Social Sciences Ethical Review Committee of the University of Queensland in Brisbane, Australia. After consent was obtained from the parents of each participant, arrangements were made to conduct the assessments.

The mean time between pretests and posttests was 21.88 months for the AVT group (SD = 1.22) and 21.65 months for the TH group (SD = 0.84), which was not significant ($t = 1.095, p = 0.279$).

4.4.1 Speech Perception

The speech perception battery was presented to children in the AVT group in a soundproof booth by experienced pediatric audiologists at the child’s AVT program center. All speech perception tests were given either by live voice or by recorded voice and in the best aided condition. For children with cochlear implants, the child’s optimally functioning MAP, as assessed by an audiologist and an auditory-verbal therapist, was used. Both “T” levels (threshold, or minimum amount of current allowing sound to be detected) and “C” levels (maximum amount of current causing discomfort) for the child’s MAP were measured behaviorally and confirmed objectively where necessary. Optimal implant performance was verified by the stability of the MAP, and consistent identification by the child of the seven sound test, the Australian adaptation of Ling’s Six Sound Test (Romanik, 1990). The “Ling sounds” are a range of speech sounds encompassing the frequencies that are widely used clinically to verify the effectiveness of hearing aid fitting in children (Agung, Purdy, & Kitamura, 2005). The Ling Six Sound Test was originally developed for the North American population (Ling, 2002), and in the seven sound test, /ɔ/ was added to account for the differences in the production and spectral content of Australian vowels (Agung et al., 2005). Optimal implant performance was also verified through the use of other speech perception tests and the cochlear implant-assisted audiogram (a record of the child’s cochlear implant-aided thresholds for responses at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz). For the children who wore hearing aids, best aided condition was determined by an audiologist and an auditory-verbal therapist, performance of the seven sound test, speech perception tests, and the child’s aided audiogram.
4.4.2 Language and Speech

The AVT group’s assessments took place at the child’s program center. For the TH group, testing was performed either at the head office of the child’s AVT program, at the child’s education setting in a quiet room, or at the child’s home. Speech and language testing was performed by experienced and qualified speech-language pathologists. Because of geographic constraints, the most convenient and available qualified staff performed the testing, and frequently, different testers assessed the children at the pretest and posttest. Tester reliability was not examined in the standardized assessments, as these were administered according to the standardized instructions in the test manuals. For the CASALA (Computer Aided Speech and Language Analysis; Serry, Blamey, Spain, & James, 1997), inter-rater reliability was performed by having each of the speech-language pathologists perform an analysis on the samples of the same 8 children. The pair-wise intertester reliability ranged from 79% to 82% for broad transcription. These levels were similar to those obtained by Shriberg, Austin, Lewis, Sweeney, and Wilson (1997), who also used CASALA to study speech development in children. The language and speech tests were administered over one session if possible; however, several children required two sessions because of age or attention difficulties. Children were given rest breaks between assessments, and the session was discontinued if a child showed evidence of fatigue or distress. The children’s responses to the GFTA-2 were not transcribed and scored at a later date. Instead, whether consonant production was correct or not was decided by the tester at the time of testing.

The order of presentation of the standardized tests used was as follows. For the pretest, the AVT group were first administered the PLS-4 or CELF-3, the PPVT-3, and the GFTA-2. A spontaneous speech sample for CASALA analysis was tape recorded at this time. The group also received speech perception assessments and a parent survey. The order of testing for the TH group was different from the AVT group in order to account first for screening and then to establish a match with a child in the AVT group before the child was unnecessarily tested. The TH group was initially screened using pure-tone audiometry in both ears to determine thresholds at 500 Hz, 1000 Hz, 2000 Hz, and 4000Hz. Thresholds needed to be within the range of 0–20 dB HL at all frequencies for both ears for inclusion in the TH group. If a child passed the screen, no further audiological tests were given to the TH group. Middle ear status was not checked unless the parent reported recent ear pain or reduced hearing. The GFTA-2 screen was also performed in the same initial session. Children who passed the screen were administered the PLS-4 or CELF-3 and the PPVT-3 for matching purposes. The TH group children were then matched for total language,
receptive vocabulary, gender, and socioeconomic level with the AVT group. At posttest, both groups received the same assessments, without the screening for the children in the TH group.

### 4.4.3 CASALA

A 5- to 7-minute spontaneous speech sample of each child with hearing loss was videotaped under predefined conditions at pretest and at posttest. These conditions included using a wall-mounted video camera, not easily identified and set 2 meters above the ground, allowing for full vision of the child’s face. The child was seated in a high chair at a table 3 meters from the camera, with a high-quality microphone set on the table at 1 meter from the child. The parent was seated at the child’s best hearing ear and was given instructions to interact with the child using a set group of toys. The parent was also given specific instructions that the session was not a therapy lesson but a play activity. The choice of toys was grouped under different scenarios (“babies,” “transport,” “animals,” and “craft”). The aim was to obtain a sample of approximately 50 utterances, or 250 words.

### 4.5 RESULTS

#### 4.5.1 Speech Perception

The speech perception results for the AVT group on a battery of speech perception tests and results for the changes in scores at pretest and posttest are summarized in Table 4.4. Box plots were generated that showed some skewness in some variables at the 21-month posttest. Where possible and appropriate, changes in speech perception skills from pretest to posttest were tested for significance using a Wilcoxon signed rank test, and the results are also reported in Table 4.4. In two subtests, PLOTT Phoneme Detection (100% at pretest \([n = 25]\) and 100% at posttest \([n = 24]\)) and CNC Vowels (95% at pretest \([n = 11]\) and 98.18% at posttest \([n = 22]\)), there was a ceiling effect at both pretest and posttest for some children, and statistical testing was not conducted. The tests were readministered at the posttest because testers were careful to check that hearing levels were consistent over time.

Also, not all tests were administered to each child because the AVT group had a wide range of speech perception abilities, which the battery of tests was chosen to cover. If a child had not attempted a test because it was too difficult, only the child’s responses on the tests that were
attempted were scored. The number of children completing more difficult recorded assessments was sometimes too few for analysis. The assessments that showed significant average improvement were PLOTT Phoneme Imitation (n = 24 at both pretest and posttest); Manchester Junior Words/PBK Words with Word Score (n = 18 at both pretest and posttest); Phoneme Score (n = 18 at both pretest and posttest); CNC Words with Phoneme Score (n = 10 at pretest and n = 24 at posttest), Consonant Score (n = 11 at pretest and n = 22 at posttest); Word Score (n = 11 at pretest and n = 22 at posttest); and BKB Sentences Live Voice (n = 10 at pretest and n = 24 at posttest). All of these tests were administered via live voice (maximum 65dB) in a quiet setting.
Table 4.4 AVT group speech perception results at pretest and posttest (expressed as percentage correct) for PLOTT Phoneme Detection, Manchester Junior Words, CNC Words, and BKB Sentences

<table>
<thead>
<tr>
<th>Name of Test</th>
<th>Pretest</th>
<th></th>
<th>Posttest</th>
<th></th>
<th>Wilcoxon z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean Score %</td>
<td>n</td>
<td>Range</td>
<td>n</td>
<td>Mean Score %</td>
</tr>
<tr>
<td>PLOTT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoneme Detection</td>
<td>25</td>
<td>100</td>
<td>0</td>
<td>100–100</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>Phoneme Imitation</td>
<td>25</td>
<td>66.47</td>
<td>12.04</td>
<td>45–100</td>
<td>24</td>
<td>79.51</td>
</tr>
<tr>
<td>Manchester Junior Words/PBK Words</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoneme Score</td>
<td>8</td>
<td>75.68</td>
<td>13.43</td>
<td>50–100</td>
<td>8</td>
<td>90.87</td>
</tr>
<tr>
<td>Word Score</td>
<td>18</td>
<td>45.8</td>
<td>21.18</td>
<td>40–75</td>
<td>18</td>
<td>75</td>
</tr>
<tr>
<td>CNC Words Live Voice (Quiet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoneme Score</td>
<td>10</td>
<td>80.82</td>
<td>16.15</td>
<td>55–100</td>
<td>2</td>
<td>5.97</td>
</tr>
<tr>
<td>Vowel Score</td>
<td>11</td>
<td>95.64</td>
<td>6.05</td>
<td>80–100</td>
<td>22</td>
<td>98.18</td>
</tr>
<tr>
<td>Consonant Score</td>
<td>11</td>
<td>73.36</td>
<td>21.09</td>
<td>36–98</td>
<td>22</td>
<td>80</td>
</tr>
<tr>
<td>Word Score</td>
<td>11</td>
<td>54.64</td>
<td>29.06</td>
<td>36–98</td>
<td>2</td>
<td>61.18</td>
</tr>
<tr>
<td>CNC Words Recorded 65dBA (Quiet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoneme Score</td>
<td>4</td>
<td>75.5</td>
<td>9.57</td>
<td>64–86</td>
<td>9</td>
<td>73.17</td>
</tr>
<tr>
<td>Vowel Score</td>
<td>4</td>
<td>80.85</td>
<td>24.90</td>
<td>44–87</td>
<td>9</td>
<td>86.67</td>
</tr>
<tr>
<td>Consonant Score</td>
<td>4</td>
<td>76.85</td>
<td>10.73</td>
<td>62–84</td>
<td>9</td>
<td>69</td>
</tr>
<tr>
<td>Word Score</td>
<td>4</td>
<td>58.98</td>
<td>25.07</td>
<td>36–92</td>
<td>9</td>
<td>48.77</td>
</tr>
<tr>
<td>BKB Sentences</td>
<td>BKB Sentences Live Voice (Quiet)</td>
<td>BKB Sentences Recorded 65dBA (Quiet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------------</td>
<td>-------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 64.5 26.30 26–94 24 79.71 19.82 33–100</td>
<td>2 81 24.04 64–98 11 66.23 20.81 26–90 not tested</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = Acceptable level of significance is ≤ 0.05
- = Not applicable
4.5.2 Standardised Language and Speech Assessments

Table 4.5 contains a summary of the age-equivalent scores of the pretests and posttests for both groups on total language, receptive vocabulary, and speech. Paired sample $t$-tests were used to investigate change scores in each group. Two children from each group had reached the ceiling of the PLS-4 and were tested on the CELF-3 for language, but separate auditory comprehension and oral expression scores are not available for the CELF-3. Therefore, only 23 pairs were analyzed for these parameters, but 25 total language scores expressed as age equivalents were included in the analysis. The age-equivalent scores for the AVT group for auditory comprehension were 3.56 years at pretest (SD = 1.06) and 5.17 years (SD = 0.7) at posttest, which showed significant improvement ($t = 10.28, p = < 0.001$). Similarly, for oral expression, the AVT group had age-equivalent scores of 3.30 years (SD = 1.02) at pretest and 5.27 years (SD = 0.96) at posttest, which was also significant ($t = 15.99, p = < 0.001$). Significant improvements were found over time for both groups for total language, receptive vocabulary, and speech skills (see Table 4.5).
Table 4.5 Mean age equivalents, standard deviations, \(t\) and \(p\) values, for total language, receptive vocabulary and speech for the 25 children in the AVT and TH groups at pretest and 21 months posttest

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Statistical Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Total Language (PLS-4/</td>
<td>AVT</td>
<td>25</td>
<td>3.58</td>
<td>1.33</td>
</tr>
<tr>
<td>CELF-3)</td>
<td>TH</td>
<td>25</td>
<td>3.46</td>
<td>1.39</td>
</tr>
<tr>
<td>Receptive Vocabulary</td>
<td>AVT</td>
<td>25</td>
<td>2.79</td>
<td>1.29</td>
</tr>
<tr>
<td>(PPVT-3)</td>
<td>TH</td>
<td>25</td>
<td>2.86</td>
<td>1.32</td>
</tr>
<tr>
<td>Speech (GFTA-2)</td>
<td>AVT</td>
<td>25</td>
<td>3.02</td>
<td>1.33</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>25</td>
<td>3.45</td>
<td>1.35</td>
</tr>
</tbody>
</table>

* = Acceptable level of significance is \(\leq 0.05\)
Between-group t-tests were used to investigate possible differences in change scores from pretest to posttest for both groups. The change scores for both groups were not significantly different for auditory comprehension (\(t = 1.44, p = 0.157\)), oral expression (\(t = 0.21, p = 0.834\)), total language (\(t = 0.12, p = 0.905\)), or speech skills (\(t = 0.8, p = 0.936\)). However, the change scores were significantly different for receptive vocabulary (\(t = 3.44, p = 0.001\)) with the TH group showing significantly greater improvement than the AVT group.

4.5.3 CASALA Speech Assessment

A within-subject analysis of variance (ANOVA) was used to analyze the AVT group’s CASALA results for percentage consonants attempted and percentage correct (see Table 4.6). The ANOVA showed that there were significant differences between the percentage of consonants attempted at the two points in time (\(F = 63.59, p < 0.0001\)), and that these differences varied for different consonants. Paired t-tests were subsequently conducted to determine if there was a difference between the number of consonants attempted at pretest and at posttest (Table 4.6). These tests showed that for five consonants (\(/n/, /ʃ/, /s/, /ʃ/,\) and \(/l/)\), there was strong evidence for an increase over time (\(p \leq 0.006\)). A conservative level of \(p\) was chosen to guard against Type 1 error. For six additional consonants (\(/m/, /t/, /k/, /f/, /ð/,\) and \(/z/)\), there was less strong evidence for an increase over time (\(p < 0.05\)). However, the percentage increase varied depending on the particular consonant being attempted.
Table 4.6 Summary of CASALA scores (percentage) and statistical tests of change over time for AVT group consonants attempted and consonants correctly produced

<table>
<thead>
<tr>
<th>Consonant</th>
<th>Attempts</th>
<th></th>
<th></th>
<th></th>
<th>Correct</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest Mean (SD)</td>
<td>Posttest Mean (SD)</td>
<td>t</td>
<td>p</td>
<td>Pretest Mean (SD)</td>
<td>Posttest Mean (SD)</td>
<td>t</td>
<td>p</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/m/</td>
<td>15.00 (9.52)</td>
<td>19.59 (7.16)</td>
<td>2.08</td>
<td>&lt; 0.05</td>
<td>96.3 (1.12)</td>
<td>95.9 (1.01)</td>
<td>0.89</td>
<td>0.377</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/n/</td>
<td>26.00 (16.12)</td>
<td>36.73 (10.58)</td>
<td>2.84</td>
<td>&lt; 0.006</td>
<td>77.8 (2.16)</td>
<td>91.3 (0.79)</td>
<td>1.97</td>
<td>&lt; 0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ŋ/</td>
<td>5.10 (3.05)</td>
<td>6.68 (1.50)</td>
<td>1.41</td>
<td>0.158</td>
<td>60.1 (2.47)</td>
<td>78.3 (1.06)</td>
<td>2.49</td>
<td>&lt; 0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/w/</td>
<td>10.50 (6.37)</td>
<td>13.73 (7.94)</td>
<td>1.24</td>
<td>0.215</td>
<td>94.3 (0.61)</td>
<td>95.4 (1.00)</td>
<td>0.56</td>
<td>0.577</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/j/</td>
<td>5.64 (4.56)</td>
<td>12.00 (6.71)</td>
<td>3.82</td>
<td>&lt; 0.006</td>
<td>92.7 (1.93)</td>
<td>92.9 (1.03)</td>
<td>1.66</td>
<td>0.097</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/p/</td>
<td>12.78 (10.78)</td>
<td>14.82 (6.39)</td>
<td>1.56</td>
<td>0.120</td>
<td>81.4 (3.30)</td>
<td>94.1 (1.12)</td>
<td>2.76</td>
<td>&lt; 0.006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/b/</td>
<td>13.61 (14.38)</td>
<td>12.18 (7.68)</td>
<td>0.93</td>
<td>0.354</td>
<td>90.4 (2.48)</td>
<td>97.6 (1.00)</td>
<td>2.24</td>
<td>&lt; 0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/t/</td>
<td>30.30 (17.03)</td>
<td>42.82 (15.76)</td>
<td>2.73</td>
<td>&lt; 0.05</td>
<td>40.7 (0.64)</td>
<td>49.1 (1.15)</td>
<td>0.57</td>
<td>0.564</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/d/</td>
<td>13.96 (9.05)</td>
<td>19.14 (11.62)</td>
<td>1.78</td>
<td>0.078</td>
<td>73.5 (0.29)</td>
<td>78.0 (1.15)</td>
<td>-0.26</td>
<td>0.797</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symbol</td>
<td>Mean (SD)</td>
<td>Variance (SD)</td>
<td>Median</td>
<td>p-value</td>
<td>Mean (CI)</td>
<td>Variance (CI)</td>
<td>Median (CI)</td>
<td>p-value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>--------------</td>
<td>--------</td>
<td>---------</td>
<td>----------</td>
<td>--------------</td>
<td>-------------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/k/</td>
<td>16.70 (9.04)</td>
<td>24.59 (10.91)</td>
<td>2.55</td>
<td>&lt; 0.05</td>
<td>64.6 (3.05)</td>
<td>89.6 (1.15)</td>
<td>2.74</td>
<td>&lt; 0.006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/g/</td>
<td>8.62 (6.25)</td>
<td>9.73 (6.73)</td>
<td>0.88</td>
<td>0.380</td>
<td>62.3 (7.81)</td>
<td>93.6 (1.15)</td>
<td>5.26</td>
<td>&lt; 0.006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/f/</td>
<td>6.11 (4.47)</td>
<td>6.90 (3.66)</td>
<td>2.03</td>
<td>&lt; 0.05</td>
<td>62.7 (2.50)</td>
<td>97.2 (0.99)</td>
<td>4.30</td>
<td>&lt; 0.006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/v/</td>
<td>4.59 (3.16)</td>
<td>5.70 (4.14)</td>
<td>1.75</td>
<td>0.081</td>
<td>63.9 (2.68)</td>
<td>82.8 (1.09)</td>
<td>2.11</td>
<td>&lt; 0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/θ/</td>
<td>2.65 (2.06)</td>
<td>3.68 (2.58)</td>
<td>1.93</td>
<td>0.054</td>
<td>49.9 (1.87)</td>
<td>76.8 (1.13)</td>
<td>1.43</td>
<td>0.154</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ð/</td>
<td>15.29 (11.65)</td>
<td>19.32 (12.31)</td>
<td>1.98</td>
<td>&lt; 0.05</td>
<td>35.3 (1.15)</td>
<td>64.7 (5.23)</td>
<td>1.87</td>
<td>0.626</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/s/</td>
<td>15.69 (9.64)</td>
<td>24.91 (12.72)</td>
<td>3.23</td>
<td>&lt; 0.006</td>
<td>74.6 (1.12)</td>
<td>86.6 (1.04)</td>
<td>2.49</td>
<td>&lt; 0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/z/</td>
<td>8.00 (6.78)</td>
<td>11.14 (9.07)</td>
<td>2.17</td>
<td>&lt; 0.05</td>
<td>74.7 (1.17)</td>
<td>83.6 (1.02)</td>
<td>0.96</td>
<td>0.336</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ʃ/</td>
<td>2.56 (2.03)</td>
<td>4.85 (3.25)</td>
<td>2.86</td>
<td>&lt; 0.006</td>
<td>93.3 (1.32)</td>
<td>98.2 (1.04)</td>
<td>0.91</td>
<td>0.367</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ʒ/</td>
<td>3.53 (2.67)</td>
<td>3.40 (3.89)</td>
<td>0.29</td>
<td>0.774</td>
<td>62.9 (1.45)</td>
<td>90.8 (1.15)</td>
<td>2.15</td>
<td>&lt; 0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/dʒ/</td>
<td>2.31 (1.70)</td>
<td>2.71 (2.30)</td>
<td>0.45</td>
<td>0.656</td>
<td>47.9 (1.46)</td>
<td>75.1 (1.23)</td>
<td>0.22</td>
<td>0.830</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/h/</td>
<td>7.70 (6.11)</td>
<td>8.55 (6.62)</td>
<td>0.87</td>
<td>0.384</td>
<td>88 (1.12)</td>
<td>94.3 (1.12)</td>
<td>1.75</td>
<td>0.080</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/l/</td>
<td>14.42 (9.45)</td>
<td>21.86 (11.76)</td>
<td>2.90</td>
<td>&lt; 0.006</td>
<td>65.6 (65.6)</td>
<td>69.1 (1.19)</td>
<td>0.01</td>
<td>0.993</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Note: Significant differences are highlighted in boldface type.

The mean increase in percentage of consonants produced correctly was also analyzed using within-subject ANOVA. There was evidence of a significant increase in percentage consonants correct from pretest to posttest ($F = 16.32$, df = 387, $p = < 0.0001$). Paired $t$-tests showed measurable significant increases for four consonants (/p/, /k/, /g/, and /f/; $p = \leq 0.006$), and positive but less strong evidence for six consonants (/n/, /ŋ/, /b/, /v/, /s/, and /ʃ/; $p = < 0.05$).
4.6 DISCUSSION

The results showed that the AVT group made significant progress over a 21-month period in speech perception, auditory comprehension, oral expression, total language, and speech skills. Results also proved that the developmental progress of the AVT group for auditory comprehension, oral expression, total language development, and speech skills over a 21-month period was the same as that for the TH group. Both groups made the same progress in auditory comprehension, oral expression, and total language development as measured on the PLS-4 or the CELF-3 as well as speech skills as measured on the GFTA-2. However, a significant advantage was found in the TH group for receptive vocabulary as measured by the PPVT-3. Nevertheless, the AVT group scored within the typical range of the PPVT-3 for receptive vocabulary.

The AVT group showed significant improvement in speech perception skills for live-voice stimuli over the 21 months. It is suggested this may be a product of both their experience with their hearing devices and the effects of AVT, but this study does not provide adequate evidence to prove the latter point. Improvements in speech perception following hearing aid fittings or cochlear implantation are well documented (e.g., Blamey et al., 2001; Svirsky, Teoh, & Neuburger, 2004). However, while increasing numbers of the children in the study were able to perform open-set, live-speech perception tasks over time, it was much more difficult when the speech was a recorded signal; only small numbers of children were able to complete the tests administered via recording. Chute and Nevins (2000) have advocated for the use of live-voice testing with this population, as recorded-voice testing is too difficult for them.

The developmental progress for language skills of the AVT group was at the same rate as the TH group, and also the same as that expected for the population of children with typical hearing. Another study, of developmental progress of total language in children with hearing loss was conducted by Blamey et al. (2001). The children in that study attended a listening and spoken language program and had a mean PTA of 78 dB HL. Findings indicated that these children, on average, progressed at half to two-thirds the rate expected for children with typical hearing; however, a typical hearing control group was not included in the research by Blamey and others (2001). This rate of development was not as fast as in the
present study; however, it is not possible to draw definitive conclusions about the reasons, as other variables, beyond the type of educational intervention, may be involved.

At the 21-month posttest, the majority of children in the AVT group (84%; 21/25) had total language scores within the age-appropriate range (i.e., ± 1 SD or above) for their chronological age. At the pretest, only 55% (16/29) of the group had age-appropriate total language scores. At the posttest, 84% (21/25) were within the typical range for receptive language, and 80% (20/25) were within the typical range or above for expressive language. At posttest, 2 children in the AVT group had language test scores that were more than 2 SD above the mean, while a further 2 children had scores that were more than 1 SD above the mean for their chronological age. Four children in the AVT group had scores that were 1 SD below the mean. These results for language contrast with the results of Geers, Nicholas, and Sedey (2003), who reported that only 30% of 181 children ages 8 to 9 years old with cochlear implants (received implants before 5 years of age) scored within the typical range for receptive language, and 47% did so for expressive language. However, in the Geers et al. (2003) study, the mean age of implantation was 3.5 years and may have been influential, as the mean age of implantation for the AVT children in the present study was 2.29 years and the median age of implant was 1.92 years.

The change in PPVT-3 scores for the TH group was significantly higher than the change for the AVT group, with the TH group progressing 33.68 months in 21 months compared to 23.8 months for the AVT group. Nevertheless, the mean score for the AVT group was within the typical range for the test. Similar results were found by Schorr, Roth, and Fox (2008), who reported a statistically significant difference between PPVT-3 scores for a group of 39 children who are congenitally deaf, use a cochlear implant, and attend a range of different educational programs, and a matched group of children with typical hearing. As in the present study, the mean score for the children with hearing loss was still within the typical range for the test. Similarly, Pittman, Lewis, Hoover, and Stelmachowicz (2005) found that PPVT-3 scores for 37 children with moderate sensorineural hearing loss were consistently poorer when compared to scores for 60 children with typical hearing, with 5 children scoring more than 1 SD below the mean. The type of educational approach the children with hearing loss had experienced was not specified, but the authors concluded that children with hearing loss in that study had significantly less ability to learn new vocabulary than children with typical hearing.
The speech skill results for the AVT group show that their rate of progress for acquisition of consonants on the GFTA-2 was statistically the same as for the TH group. Articulation of consonants has been shown to be the major factor in speech intelligibility (Ling, 2002). At the start of the study, the results of consonant articulation for the AVT group were not statistically different from the TH group. This may reflect the fact that the children were matched for language age and had been in the AVT program for a mean of 20 months at the pretest. The excellent developmental results for speech found in the present study for the AVT group disagree with Marschark, Lang, and Albertini (2002), who reported that articulation skills are a primary area of difficulty for this population. They also disagree with Eisenberg (2007), who reported that the speech development of children with even a mild-to-moderate hearing loss is delayed. These results are in agreement with those of Schorr and others (2008), who compared GFTA-2 results for 39 children with cochlear implants (ages 5 to 14 years) with those of a group of children with typical hearing, matched for gender and chronological age. They found that the mean scores of the children with cochlear implants were within 1 SD of the mean for the typical hearing group. The speech progress rate for the AVT group may have been the effect of experience following amplification with hearing aids or a cochlear implant (e.g., Allen, Nikolopoulos, & O’Donohue, 1998), better language skills (Coerts & Mills, 1995; Svirsky, 2000; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000), or an emphasis on communicating with listening and spoken language (Tobey, Geers, Brenner, Altuna, & Gabbert, 2003). However, an interaction of factors is the most likely explanation for improved speech.

Research has indicated that the combination of the use of listening and spoken communication plus early, intensive, speech intervention increases the likelihood that children with significant hearing loss can acquire speech skills that are comparable to children with typical hearing of the same age, at least at the isolated single-word level (Schorr et al., 2008). The AVT group in the present study had attended the AVT program for a minimum of 4 years, wore their amplification technology constantly, used listening and spoken language communication, had language skills that were not significantly different from the TH group, and received early, intensive speech intervention as an integral part of their AVT program.

In addition to the positive findings for articulation of individual consonants in single words, the study of consonant development in spontaneous speech using CASALA indicated
that the AVT group’s acquisition of consonants appeared to follow the typical developmental sequence of consonants for Australian children (Kilminster & Laird, 1978). These results are in agreement with an early study by Serry, Blamey, and Grogan (1997), who found that the speech of children with cochlear implants followed a development similar to that of children with typical hearing.

The present research has addressed some of the criticisms reported in studies on outcomes of AVT by including a control group and carefully matching the participants in both groups, thereby providing a higher level of evidence (Oxford Centre for Evidence Based Medicine, 2001). The study design was prospective and included standardized assessments, and assessments were made at multiple points over time for both the AVT and TH groups. Also, the reasons for children dropping out of the study were described. The authors acknowledge that this group of children had minimal other disabilities, spoke only English, and were from relatively high-level socioeconomic backgrounds, which might reduce the comparability of this population with others. Further research is necessary to investigate the influence of socioeconomic status on outcomes for children with hearing loss, to determine the most appropriate way to measure this variable, and to determine if access to AVT services due to of socioeconomic level affects outcomes for a range of populations.

4.7 CONCLUSION

Overall, the AVT group of children maintained their promising developmental progress for auditory comprehension and oral expression, total language, and articulation of consonants demonstrated in the first 9 months of this study (Dornan et al., 2007). They continued this developmental progress at a rate statistically the same as that of the TH group of children who were matched for initial language age, receptive vocabulary, gender, and socioeconomic level. However, after the 9-month point, the TH group accelerated their progress for receptive vocabulary skills, performing significantly better than the AVT group. Nevertheless, acquisition of receptive vocabulary for the AVT group also progressed steadily at a rate similar to that of children with typical hearing (a change of 23.76 months in a 21-month period), with the vast majority (84%) achieving scores that were age appropriate. This study will now continue to be extended longitudinally, using the same tests but with the addition of measures of literacy, numeracy, and self-esteem as the majority of the children enter formal schooling. In summary, for this particular population of children with hearing
loss, AVT was found to be an effective communication option, but more information is needed over longer time periods and with different populations.
4.8 REFERENCES


CHAPTER FIVE

Outcomes for Children with Hearing Loss in an Auditory-Verbal Therapy Program: Results at the 38 Months Posttest

Dornan, D., Hickson, L., Murdoch, B., Houston, T., & Constantinescu, G. Manuscript in preparation for publication.

This chapter contains the results measured at the 38 months posttest and is an adaptation of the manuscript entitled “Outcomes for children with hearing loss in an Auditory-Verbal Therapy program over 38 months” being prepared for submission for publication. The method and procedure are similar to those reported in Chapters 3 and 4 and are therefore not repeated in full here.
5.1 INTRODUCTION

This chapter reports the outcomes for the continuation of the longitudinal research study over 38 months, including the results for additional assessments of reading, mathematics and self-esteem. The aim was to investigate the outcomes for speech and language for 23 of the original children who had remained in the study from the pretest to the 38 months posttest, compared with the outcomes for their matched pairs from the TH group. Speech perception for both live and recorded voice was also assessed for the AVT group from the 21 months posttest to the 38 months posttest and is reported here. As most of the children had entered school by the 38 months posttest, assessments of reading, mathematics and self-esteem were added at this point of the study for both groups of participants. These additional assessments were included to investigate whether or not the good language skills found previously (Dornan et al., 2007; 2009) were associated with positive reading, mathematics and self-esteem levels.

This introduction focuses on the impact of hearing loss on reading, mathematics and self-esteem, the new areas assessed at the 38 months posttest. Literature citations relevant to speech perception and speech and language are included in other sections of the thesis. The reading skills of children with significant hearing loss have been reported as severely affected (Marschark, Rhoten, & Fabich, 2007; Traxler, 2000). By the time they reach late primary and high school, reading results for children with cochlear implants have been reported as poor, with a significant proportion of these children never achieving functional literacy (Geers, 2003; Vermeulen, van Bon, Schreuder, Knoors, & Snik, 2007). Similarly, Traxler (2000) found that children with severe to profound hearing loss typically completed 12th grade with 3rd- to 4th-grade reading levels. Some studies of children from AVT programs have been more promising (Robertson & Flexer, 1993; Wray, Flexer, & Vaccaro, 1997), however further research is necessary to substantiate these findings.

A review between 1980 and 2000 of mathematics abilities of children with hearing loss showed that these children lag behind children with typical hearing by 2 to 3.5 years (Swanwick, Oddy, & Roper, 2005); more recent studies are rare. However it has been proposed that mathematics ability in children with hearing loss may be affected because these abilities are related to language, reading and morphological knowledge of word segmentation and meaning (Kelly & Gaustad, 2007). As well as reduced access to hearing, it
has been reported that reduced opportunities for incidental learning, as well as difficulty in making inferences involving time sequences, can result in a risk of underachievement in mathematics for children with hearing loss (Nunes & Moreno, 2002). There are, however, no studies in the literature of mathematics’ abilities of children with hearing loss in AVT programs. There are a number of reports on the self-esteem of children with severe to profound hearing loss, which report significantly reduced emotional development and poor self-esteem in these children (Bat-Chava, Martin, & Kosciw, 2005; Crouch, 1997; Hintermair, 2006; Lane & Grodin, 1997; Nicholas & Geers, 2003). There are no studies on the self-esteem of children educated with AVT. Consequently, a self-esteem assessment was included here to explore this issue.

In summary, this study had three aims. Firstly, it aimed to investigate speech perception development for the AVT group from the 21 months posttest to the 38 months posttest. This time span ensured that adequate numbers of children were able to perform similar speech perception tests at both time points. Speech perception was not tested for the TH group because it was anticipated that they would achieve high scores and that this testing was unnecessary. Secondly, the study aimed to investigate whether the AVT group made significant progress in receptive, expressive and total language, receptive vocabulary, and speech skills (acquisition of consonants in words) over 38 months, and whether this progress was the same as for the TH group. Thirdly, the study aimed to compare the levels of reading, mathematics and self-esteem between groups at the 38 months posttest.

5.2 METHOD

The research design and participant recruitment details are the same as described in Chapter 3.

5.2.1 Participants

The characteristics of the 23 AVT group children in the study at the 38 months posttest are summarised in Table 5.1. The six children from the original AVT group who had withdrawn from the study by the 38 months posttest included two children with additional disorders who were subsequently transferred to a different program, and four who were
geographically unavailable. The characteristics of the 23 matched TH group children are also summarised in Table 5.1.

Table 5.1 Characteristics of AVT group and TH group at 38 months posttest

<table>
<thead>
<tr>
<th></th>
<th>AVT Group</th>
<th>TH Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Mean Age in years (SD)</td>
<td>6.96 (1.11)</td>
<td>6.21 (1.17)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Female</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Age at identification in months</td>
<td>21.37 (12.39)</td>
<td>n/a</td>
</tr>
<tr>
<td>Mean PTA better ear (SD)</td>
<td>77.16 (23.6)</td>
<td>n/a</td>
</tr>
<tr>
<td>Time of Loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congenital</td>
<td>21</td>
<td>n/a</td>
</tr>
<tr>
<td>Prelingual</td>
<td>2</td>
<td>n/a</td>
</tr>
<tr>
<td>Age at CI in months (SD)</td>
<td>27 (5.8)</td>
<td>n/a</td>
</tr>
<tr>
<td>Time spent in AV Program in months (SD)</td>
<td>58</td>
<td>n/a</td>
</tr>
<tr>
<td>Hearing Device</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HA</td>
<td>9</td>
<td>n/a</td>
</tr>
<tr>
<td>CI</td>
<td>14</td>
<td>n/a</td>
</tr>
</tbody>
</table>

5.2.2 Materials

The battery of tests of speech perception, speech and language employed is shown in Chapter 4, Table 4.3. For the speech perception tests, one of the tests in the battery used in earlier stages (Dornan et al., 2009), Manchester Junior Words/ PBK Words (Phonetically Balanced List for Kids) (Watson, 1957), was omitted because it was too easy for the AVT group at this stage. Also, the assessment of consonant sounds in discourse for the AVT group was omitted at the 38 months posttest as this became too lengthy as speech development accelerated. Other differences between this and earlier stages of the research were the
addition of assessments for reading, mathematics and self-esteem; these are described in Table 5.2.
**Table 5.2 Battery of reading, mathematics and self-esteem assessments added at 38 months posttest**

<table>
<thead>
<tr>
<th>Test</th>
<th>Description of Test</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reading</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading Progress Tests (RPT). (Vincent &amp; Crumpler, 1997).</td>
<td>Stage I is used in the first 3 years of school and assesses pre-reading and early reading skills in first year of school and reading comprehension in the second and third years of school. Stage 2 is used for school years 3 – 6 and assesses outcomes for reading by assessing a range of literal and inferential skills and reading vocabulary. Australian norms were available.</td>
<td>One mark is awarded for each correct answer. No marks are awarded for multiple choice questions where more than one choice has been selected. Score is expressed as a percentile rank.</td>
</tr>
<tr>
<td><strong>Mathematics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I Can Do Maths (Doig &amp; de Lemnos, 2000)</td>
<td>Assesses numeracy development in first 3 years of school. Australian norms were available.</td>
<td>One mark is awarded for each correct answer. Score is expressed as a percentile rank.</td>
</tr>
<tr>
<td>Progressive Achievement Tests in Mathematics (PATMaths) (Australian Council of Educational Research, 2005)</td>
<td>Assesses mathematic achievement levels in school years 3 to 11. Australian norms were available.</td>
<td>One mark is awarded for each correct answer. Score is expressed as a percentile rank.</td>
</tr>
<tr>
<td><strong>Self-esteem</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insight (Morris, 2003)</td>
<td>This questionnaire assesses development of self-esteem from 3</td>
<td>The sum of the scores for the 3 areas were totalled</td>
</tr>
</tbody>
</table>
– 19 years of age (Preschool and Primary) and is completed by parents. There are 36 questions divided into 3 different sections: child’s sense of self, sense of belonging and sense of personal power. Parents were asked to report whether the skill was evident “Most of the Time” (3 points), “Quite Often” (2 points), “Occasionally” (1 point) or “Almost Never” (0 points). (maximum possible total = 108) and then categorized as High = 87-108, Good = 64-86, Vulnerable = 40-63, or Very Low = 0-39.
5.2.3 Procedure

Ethical clearance for this project and administration of the speech perception, speech, and language assessments were the same as for earlier stages of this study as described in Chapters 3 and 4 (Dornan et al., 2007, 2009). At this time point, tests were usually administered over two sessions as they had been previously, however many children required three sessions because of age, attention difficulties and the extra time required for reading, mathematics and self-esteem assessments. The additional reading and mathematics assessments were administered by speech-language pathologists, while self-esteem questionnaires were filled in by parents at the time of the testing.

5.3 RESULTS

As at previous time points, the matching of the children was checked by testing for differences between language and receptive vocabulary scores of the two groups at pretest. Initially, the 23 remaining children in the AVT group had a mean age equivalent for total language of 3.66 years (SD = 1.36) and the TH group’s mean age equivalent was 3.55 years (SD = 1.39). Between group t-tests showed no significant difference between these values (\( t = 1.305, p = 0.198 \)). Similarly there was no significant difference (\( t = -0.29, p = 0.771 \)) between the mean age equivalent for receptive vocabulary on the PPVT-3 for the AVT group (mean = 2.84; SD = 1.35) and the TH group (mean = 2.96; SD = 1.38) at pretest.

5.3.1 Speech Perception

Since the AVT group children were at different ages and stages of development, and a battery of speech perception tests was used, not all children completed all tests. Speech perception results for the AVT group children who had scores both at the 21 months and 38 months posttest are shown in Table 5.3. Analysis of the change in scores was performed using Wilcoxon Signed Rank tests. For the live voice tests, no significant change was found for Plott Phoneme Detection, Plott Phoneme Imitation, and CNC Words Vowel Score as the scores remained high and stable. Significant improvements were found on CNC Words Phoneme, Consonant and Word scores, and likewise, BKB Sentence scores also improved significantly over time from the 21 months to the 38 months posttests. Recorded voice scores
did not show significant improvement for CNC Words but did improve for the BKB sentences.
Table 5.3 Speech perception results for AVT group at 21 months posttest and 38 months posttest (expressed as percentage correct), z and p values for PLOTT Phoneme Detection, CNC Words, and BKB Sentences

<table>
<thead>
<tr>
<th>Name of Test</th>
<th>21 Months Posttest</th>
<th>38 Months Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Score %</td>
<td>SD</td>
</tr>
<tr>
<td><strong>PLOTT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoneme Detection (n = 18)</td>
<td>100</td>
<td>0.00</td>
</tr>
<tr>
<td>Phoneme Imitation (n = 21)</td>
<td>79.51</td>
<td>9.84</td>
</tr>
<tr>
<td><strong>CNC Words Live Voice (Quiet)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoneme Score (n = 17)</td>
<td>85.97</td>
<td>8.26</td>
</tr>
<tr>
<td>Vowel Score (n = 15)</td>
<td>98.18</td>
<td>2.68</td>
</tr>
<tr>
<td>Consonant Score (n = 17)</td>
<td>80.00</td>
<td>11.56</td>
</tr>
<tr>
<td>Word Score (n = 17)</td>
<td>61.18</td>
<td>22.66</td>
</tr>
<tr>
<td><strong>CNC Words Recorded 65dBA (Quiet)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoneme Score (n = 7)</td>
<td>73.17</td>
<td>13.41</td>
</tr>
<tr>
<td>Vowel Score (n = 7)</td>
<td>86.67</td>
<td>10.00</td>
</tr>
<tr>
<td>Consonant Score (n = 7)</td>
<td>69.00</td>
<td>14.00</td>
</tr>
<tr>
<td>Word Score (n = 11)</td>
<td>48.77</td>
<td>20.74</td>
</tr>
<tr>
<td><strong>BKB Sentences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BKB Sentences Live Voice</td>
<td>79.71</td>
<td>19.82</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>(Quiet) (n = 18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BKB Sentences Recorded 65dBA</td>
<td>66.23</td>
<td>20.81</td>
</tr>
<tr>
<td>(Quiet) (n = 11)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Acceptable level of significance = ≤0.05
5.3.2 Speech and Language

It was decided that $t$ tests were appropriate for analysis of the change in scores over time as a Kolmogorov-Smirnov test of normality revealed that the sample was not significantly different to the normal distribution ($p = 0.200$) for receptive, expressive and total language at the pretest (baseline) and at 38 months. Table 5.4 shows the mean scores for both groups for the speech and language tests, and the results of analyses using paired sample $t$ tests to determine if there was significant progress from the pretest to the 38 months posttest and using between group $t$ tests to investigate whether there was a significant difference between the change in scores obtained by the AVT and the TH group.

Both the AVT group and the TH group made significant progress in total language and speech skills, and there was no significant difference between the progress for the AVT group and the TH group. However, the TH group had a significantly greater mean improvement in receptive vocabulary than the AVT group. Nevertheless the mean score for participants in the AVT group at the 38 months posttest was within the typical range (within one standard deviation) for receptive vocabulary for the mean age of the group.

It was difficult to compare the receptive and the expressive language of the AVT and TH groups at the 38 months posttest as both groups were transitioning from the PLS-4 to the CELF-3 at different rates. The CELF-3 does not give individual age equivalents for receptive and expressive language, only standard scores that are age corrected. Twenty of the AVT group and 14 of the TH group received the CELF-3 at the 38 months posttest. There were no significant changes in the standard scores for both the AVT group ($t = -0.284; p = 0.532$) and the TH group ($t = -0.318; p = 0.754$) for receptive language from pretest to posttest. Similarly, there were no significant changes in the standard scores for both the AVT group ($t = -0.580; p = 0.954$) and the TH group ($t = -1.283; p = 0.213$) for expressive language from pretest to posttest. Also there was no significant difference between the changes in standard scores between pretest and posttest for the AVT group and the TH group for both receptive language ($t = -0.284; p = 0.639$) or for expressive language ($t = -0.708; p = 0.153$).
Table 5.4 Mean age equivalent (in years), standard deviations (in parentheses), $t$ and $p$ values for total language, receptive vocabulary, and speech for the AVT and TH groups at pretest and at 38 months posttest

<table>
<thead>
<tr>
<th>Name of Test</th>
<th>Group</th>
<th>Mean Score at Pretest (SD)</th>
<th>Mean Score at Posttest (SD)</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PLS-4/CELF-3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total language age equivalent in years (n = 23)</td>
<td>AVT</td>
<td>3.66 (1.36)</td>
<td>6.96 (2.51)</td>
<td>-9.050</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>3.55 (1.39)</td>
<td>7.22 (1.12)</td>
<td>-23.98</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td>-0.904</td>
<td>0.371</td>
</tr>
<tr>
<td><strong>PPVT-3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receptive Vocabulary in years (n = 22)</td>
<td>AVT</td>
<td>2.84 (1.35)</td>
<td>6.48 (1.81)</td>
<td>-16.329</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>2.96 (1.38)</td>
<td>7.40 (1.53)</td>
<td>-19.151</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td>-2.490</td>
<td>0.017*</td>
</tr>
<tr>
<td><strong>GFTA-2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speech skills in age equivalent in years (n = 23)</td>
<td>AVT</td>
<td>3.11 (1.36)</td>
<td>6.01 (1.31)</td>
<td>-9.243</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>3.59 (1.31)</td>
<td>6.20 (1.15)</td>
<td>-8.827</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td>-0.659</td>
<td>0.513</td>
</tr>
</tbody>
</table>

Note 1: *Acceptable level of significance = ≤0.05

Note 2: AVT group chronological age at posttest was 6.96 years (SD = 1.11).

     TH group chronological age at posttest was 6.21 years (SD = 1.17).
5.3.3 Reading and Mathematics

At the 38 months posttest, 83% of the AVT children were capable to be enrolled in mainstream school, with the remaining 17% (n = 4) too young to attend school; 46% of the TH group were attending school with 54% (n = 12) too young for school entry. There were 13 pairs of children who were able to complete assessments of reading and mathematics and a Mann-Whitney Test revealed no significant difference between the AVT group and the TH group results for both of these academic areas (Table 5.5).

Table 5.5 Summary of mean percentile ranks for reading and mathematics for the 13 pairs of children in the AVT group and TH group at 38 months posttest and results of statistical analysis of differences between groups using Mann-Whitney Tests

<table>
<thead>
<tr>
<th>Name of Test</th>
<th>Group</th>
<th>Percentile Rank (SD)</th>
<th>Range</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>AVT</td>
<td>74.08 (30.63)</td>
<td>3-96</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>79.85 (21.36)</td>
<td>23-96</td>
<td>-0.18</td>
<td>0.857</td>
</tr>
<tr>
<td>Group Comparison</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td>AVT</td>
<td>55.69 (32.48)</td>
<td>17-96</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>73.69 (29.23)</td>
<td>12-99</td>
<td>-1.50</td>
<td>0.134</td>
</tr>
</tbody>
</table>

*Acceptable level of significance = ≤0.05

For reading, 85% of the AVT group (compared with 100% of the TH group) had scores within the typical range or above and similarly for mathematics, 85% of the AVT group (compared with 93% of the TH group) had scores within the typical range or above.

5.3.4 Self-esteem

Four of the AVT group parents completed the Preschool Insight self-esteem assessment and 18 the Primary Insight. Nine of the TH group parents completed the Preschool Insight and 14 the Primary Insight. Of the 22 parents in the AVT group, 81.8% rated their child’s self-esteem as High, and 18.2% rated it as Good. For the 23 TH group parents who responded, 78.26% of parents rated their child’s self-esteem as High, and 21.74% rated it as Good. For both the AVT and TH group, no
children were rated as having self-esteem in the Vulnerable or the Very Low category. This meant that 4 matched pairs of children’s parents responded to the Preschool Insight and 14 matched pairs responded to the Primary Insight. The differences between scores for the 14 pairs assessed with the Primary Insight were compared using Mann-Whitney tests and no significant differences were found for the three subscales (see Table 5.6).

**Table 5.6** Self-esteem scores for parent responses for AVT group and TH group for 14 pairs of children using Primary Insight and statistical analysis for difference between groups using Mann-Whitney Tests

<table>
<thead>
<tr>
<th>Name of Test</th>
<th>Group</th>
<th>Mean Score (SD)</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense of Self</td>
<td>AVT</td>
<td>31.07 (3.93)</td>
<td>-0.324</td>
<td>0.746</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>31.93 (4.80)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sense of Belonging</td>
<td>AVT</td>
<td>31.64 (2.98)</td>
<td>-0.949</td>
<td>0.343</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>29.92 (5.27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sense of Personal Power</td>
<td>AVT</td>
<td>30.29 (3.79)</td>
<td>-0.946</td>
<td>0.344</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>27.36 (7.17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group Comparison</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total self-esteem</td>
<td>AVT</td>
<td>92.86 (9.46)</td>
<td>-0.621</td>
<td>0.534</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>89.93 (12.82)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Acceptable level of significance = ≤0.05

5.4 **DISCUSSION**

5.4.1 **Speech Perception**

The AVT group showed significant improvement in speech perception skills for live-voice stimuli from the 21 months to the 38 months posttests for CNC Words and BKB Sentences, while the scores for the less difficult Plott tests and CNC Words Vowel Score remained high and stable. For recorded voice, CNC Word perception did not improve but BKB Sentences did improve, suggesting that the children may have used the context of the words in the sentence to discern the
Another positive finding was that at the 38 months posttest, more of the AVT group were capable to be tested using a recorded signal, which is generally more difficult. It is suggested that these increasing speech perception skills may be a product of both their experience with their hearing devices and the effects of AVT. However, this study does not provide adequate evidence regarding the latter point. Improvements in speech perception following hearing aid fittings or cochlear implantation are well documented (e.g., Blamey, Sarant, et al., 2001; Svirsky, Teoh, & Neuburger, 2004).

5.4.2 Speech and Language

The AVT group and the TH group made significant progress for total language, receptive vocabulary and speech skills over a 38-month period and the mean changes in scores for total language, receptive vocabulary and speech were not significantly different between groups. Standard scores for receptive and expressive language did not show significant progress, but this was expected, as these scores are age corrected.

Of the AVT group, 70.3% had standard scores that were within the typical range for receptive language, 62.5% had standard scores within or above the typical range for expressive language, and 71% had age equivalent scores within or above the typical range for total language. The AVT group achieved a mean age equivalent of only 1.92 months less than their chronological mean age of 6.96 years for total language, indicating very good progress. The TH group’s mean age equivalent for total language was 11.8 months above their mean chronological age of 6.21 years. It is important to note that, as Nicholas and Geers (2007) have suggested, although the results for children with hearing loss may approach those of their hearing peers, they may not fully reflect typical language development, as not all language domains are covered by any assessment battery, including the assessments used in this current study. For example, it was not possible to test all areas of syntax or to assess pragmatics in the language assessments used, nor was it practical to do so. Even though the majority of scores on the language tests were within the normal range, there may be functional differences between language of the TH group and AVT group. The mean gain in age equivalent for total language for the AVT group over 38 months was 38.76 months, or a mean rate of progress of 12.02 months in 12 months of time (S.D. = 6.53). The TH group progressed in total language development at an average rate of 15.6 months in 12 months of time (S.D. = 2.75), which is more rapid than the AVT group although the difference in rate did not reach statistical significance.
The rate of progress obtained by children with hearing loss in this research compares favourably to other studies. For example, the rate of language progress for children in an auditory-oral program has been reported as half to two thirds the rate reported for children with TH (Blamey, Sarant, et al., 2001). In addition, Geers (2004) reported that for a nationwide group of 8 to 9 year old American children who were implanted between 24 to 35 months of age, only 43% achieved combined speech and language skills within the same range as their typically hearing peers. In addition, the finding here that the majority of the AVT children (71%) scored within the typical range for total language is similar to other studies on children who receive cochlear implants at less than 18 months of age (Dettman, Pinder, Briggs, Dowell, & Leigh, 2007; Hammes et al., 2002; Kirk, Miyamoto, Lento, Ying, & O’Neill, 2002; Svirsky Teoh, & Neuburger, 2004). However, only half of the AVT group in the present study had implants and the mean age of implant was 27 months. This highlights the positive nature of the findings. Results here are also positive when compared to Sarant, Holt, Dowell, Rickards, and Blamey (2008) who reported that only 40% of a group of children in an auditory-oral program who left the program to attend a mainstream school had language scores in the typical range at age of school entry (usually around 6 years of age in Australia).

The receptive vocabulary results showed that both groups made significant progress, and there was a significant difference between the changes in scores for the groups from the pretest to the 38 months posttest. The TH group improvement was greater than the AVT group, the same as the finding obtained at the 21 months posttest, indicating that at this stage of the study the TH group had higher receptive vocabulary scores than the AVT children. Sixty one percent of the AVT group had scores within the normal range. Nevertheless, the receptive vocabulary results for the AVT group are superior to previous studies, which have reported lower levels of receptive vocabulary for children with hearing loss compared to children with typical hearing (e.g. Blamey, Sarant, et al., 2001; Eisenberg, Kirk, Martínez, Ying, & Miyamoto, 2004; Fagan & Pisoni, 2010; Hayes, Geers, Treiman, & Moog, 2009; Schorr, Roth, & Fox, 2008; Uziel et al., 2007). The AVT group as a whole still achieved as well as peers with TH of the same chronological age, however they did not progress as rapidly as their TH controls in the present study.

The speech testing findings showed that both groups made significant progress, and there was no significant difference between the changes in scores for the two groups. The results for speech are more difficult to interpret than those for total language and receptive vocabulary, as 25% of the AVT group children and 29% of the TH group children had reached the ceiling of 7 years 8 months
on the GFTA-2 at the 38 months posttest. The majority of the AVT group children (70.8%) were within the typical range, or above it, for their age at the 38 months posttest. These results agree with Schorr, Roth and Fox (2008), who also found positive speech results for 39 implanted children (mean age = 9 years) compared with those for a group with TH matched for chronological age and gender. Tobey, Geers, Brenner, Altuna, and Gabbert, (2003) have reported that speech skills increase with longer implant experience and use of oral communication. A high correlation between speech perception and speech production has also been reported for children with cochlear implants (Phillips, Hassanzadeh, Kosaner, Martin, Deibl, & Anderson, 2009), and the AVT group in the present study had moderate to good speech perception skills. The AVT group results are better than some reports of children with hearing loss who have difficulty with articulation of consonants (Marschark, Lang, & Albertini, 2002; Schorr et al., 2008; Tobey et al., 2003; Uziel et al., 2007). It is likely that the combination of appropriate hearing devices, good speech perception skills and AVT may have positively influenced the level of speech skills achieved by the AVT group.

5.4.3 Reading and Mathematics

The results for reading and mathematics showed that the achievement levels for 13 children in the AVT group at the 38 months posttest were not significantly different from the TH group, and the majority had scores that fell within the typical range or above. Although based on a very small sample and obviously requiring further validation in subsequent research, these are promising findings. The reading results are in agreement with the work of authors who have reported positive reading skills for children educated using AVT (Flexer, 1999; Robertson & Flexer, 1993; Wray, Hazlett & Flexer, 1998). It has been argued that AVT stimulates the primary reading centres of the brain (Flexer, 1999), including phonological processing areas, which are located in the auditory cortex (Chermack & Musiek, 1997; Musiek & Berge, 1998). Phonological processing has been found to be integral to successful reading development, both in children with TH (Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh, & Shanahan, 2001; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001) and children with hearing loss (Colin, Magnan, Ecalle, & Leybaert, 2007; Easterbrooks, Lederberg, Miller, Bergeron, & Connor, 2009; Spencer & Oleson, 2008; Traxler, 2000). The preliminary mathematics results obtained here for the AVT children are better than those usually reported for children with hearing loss (Kelly & Gaustad, 2007; Nunes & Moreno, 2002; Swanwick, Oddy, & Roper, 2005; Traxler, 2000). These academic results for reading and mathematics for the AVT and TH groups were subsequently used as a baseline for the final assessments of this longitudinal study at the 50 month posttest.
5.4.4 Self-esteem

Results for 14 children in the AVT group were able to be compared with 14 in the TH group on a parent rated assessment of self-esteem levels and no significant difference in scores was found. These results are pleasing, as previous researchers have found that hearing loss can adversely affect mental health, socio-emotional development and self-esteem (Bat-Chava, 1993; Laurenzi & Monteiro, 1997; Nicholas & Geers, 2003; Prizant & Meyer, 1993). Levels of self-esteem for the AVT group were either High or Good, and as no children from either group were rated in the Vulnerable or the Very Low category, these are very positive outcomes. The self esteem results for the AVT group agree with other studies on children with cochlear implants in which positive self-esteem was reported (Percy-Smith, Jensen, Josvassen et al., 2006; Schorr, Roth & Fox, 2009). In another study of children with implants, parents rated their child’s personal-social adjustment and there was a statistically significant relationship between speech understanding, speech production, vocabulary and level of social well-being (Percy-Smith, Jensen, Cayé-Thomasen et al., 2008). As the majority of children in the current study had cochlear implants and were good users of spoken language, this may explain the positive self-esteem results.

5.4.5 Limitations

Interpretation of the outcomes of this study may be limited by the fact that the participants were from a moderate to high socioeconomic level, a fact that means that the findings cannot be generalized to children from lower socioeconomic backgrounds. Other studies on outcomes of AVT have also reported that parents of the children typically came from a well-educated group (Dornan et al, 2007; 2009; Easterbrooks, O’Rourke, & Todd, 2000; Rhoades & Chisolm, 2000). This research needs to be extended over a longer time period, with additional numbers of participants, particularly for reading and mathematics, and applied to different populations of children with hearing loss. The strengths of this study include the fact that a control group was an integral part of the research design, and that a number of domains were measured and compared over more than a three year time span.
5.5 CONCLUSION

The children in the AVT group maintained the promising results they showed earlier (Dornan et al., 2007; 2009), except that the TH group had progressed more rapidly in receptive vocabulary at this point in the study. Nevertheless, the mean AVT group score for receptive vocabulary was within the typical range for their age. The majority of the AVT group had scores within the typical range for their age for language, receptive vocabulary, speech skills, reading and mathematics and their self-esteem was rated by their parents at a similar level to the TH group.
Is Auditory-Verbal Therapy Effective for Children with Hearing Loss? 6


6This chapter contains the results measured at the 50 months posttest and is an adaptation of the manuscript entitled “Is Auditory-Verbal Therapy effective for children with hearing loss?” to be published in The Volta Review in 2010, and is inserted as accepted for publication, with the exception of formatting and wording changes to headings, tables and figures to maintain consistency throughout the thesis.
6.1 INTRODUCTION

This longitudinal study was designed for the purpose of investigating the effectiveness of AVT for a group of children with hearing loss (AVT group). Since the introduction of universal newborn hearing screening, digital hearing aids and cochlear implants, there has been increased debate about educational options for children with hearing loss. Appropriate and timely information is needed in order to guide parent and professional decision-making. However, rigorous evidence for the outcomes of any of the educational approaches in use today, including AVT, is minimal (Gravel & O’Gara, 2003; Sussman et al., 2004). Existing research studies on AVT outcomes have been criticised as being few in number and lacking in rigour (Eriks-Brophy, 2004; Rhoades, 2006). These studies also had limited generalisability because of their retrospective nature, inconsistency in the use of standardised assessments, the possibility of self-selected populations and lack of control groups.

A review of research findings on outcomes of AVT was conducted by Dornan, Hickson, Murdoch and Houston (2008). In this review, several studies were found to demonstrate a typical rate of progress for language development for children in AVT programs (Hogan, Stokes, White, Tyszkiewicz, & Woolgar, 2008; Rhoades, 2001; Rhoades & Chisolm, 2000). However, these findings needed substantiation with a controlled study. Such comparisons were undertaken in the earlier stages of this research where outcomes of the AVT group were compared with those for a matched group of children with typical hearing (TH group) (Dornan, Hickson, Murdoch, & Houston, 2007; 2009). At baseline, there were 29 children in the AVT group aged between 2 to 6 years (mean pure tone average of 76.17dB HL). The children were matched with typical hearing children for initial language age, receptive vocabulary, gender and socioeconomic status as measured by head of the household education level. Both groups were assessed over time using a battery of assessments. Speech and language outcomes for the AVT group were compared with those for the TH group from baseline (referred to as the pretest) to 9, 21, 38 and 50 months after the baseline (referred to as the posttests). Results of these earlier studies have been positive, with the AVT group showing significant progress for speech and language at the same rate as the TH group (Dornan et al., 2007; 2009). An exception was receptive vocabulary, for which the AVT group achieved the same progress as the TH group at the 9 months posttest \((p > 0.05)\) (Dornan et al., 2007), but at the 21 and 38 months posttests, the TH group scored significantly higher than the children in the AVT group \((p \leq 0.05)\) (Dornan et al., 2009). Despite this difference, the AVT children’s mean age equivalent was within the typical range for their chronological age.
Further study on the outcomes for the AVT group is important, because few controlled studies of speech and language outcomes over a long time frame are available for children with hearing loss. In addition, an extension of the study time allowed us to include measures of academic outcomes for the children. It is widely acknowledged that significant hearing loss in children also impacts on academic achievement, which usually lags behind the norm for children with typical hearing (Powers, 2003). Academic success for a child with hearing loss in the mainstream has been linked with a number of factors, including an oral education, shorter period of hearing loss prior to amplification or cochlear implantation, and level of intelligence (Damen, van den Oever-Goltstein, Langereis, Chute, & Mylanus, 2006; Geers, Brenner, Nicholas, Uchanski, Tye-Murray, & Tobey, 2002). The fundamental academic skill of reading is often severely affected by significant hearing loss, with many children never achieving functional literacy (Moeller, Tomblin, Yoshinaga-Itano, Connor, & Jerger, 2007; Vermeulen, van Bon, Schreuder, Knoors, & Snik, 2007). Traxler (2000) found that children with severe to profound hearing loss typically completed 12th grade with language levels of 9- to 10-year-old hearing children, and 50% of students read at a reading level of 4th grade or less. Reports such as these are in contrast to two studies on the reading of children in an AVT program (Robertson & Flexer, 1993; Wray, Flexer, & Vaccaro, 1997), which found that children were able to read at or above age appropriate levels. However, as the previous research did not include control groups and used different assessments, the interpretation of findings and close comparison of results are difficult.

Poor consistency has also been reported among studies on the reading development of children with hearing loss using the various education approaches (Marschark, Rhoten, & Fabich, 2007). Spencer and Oleson (2008) studied the reading of 72 children with hearing loss who had used unspecified education approaches (after 48 months of cochlear implant use) and concluded that early access to sound helped to build better phonological processing skills, one of the likely contributors to reading success (National Institute of Child Health and Human Development, 2000). Spencer and Oleson (2008) also found that 59% of variance in reading skills for these children could be explained by early speech perception and speech production performance. However, other researchers found that although early cochlear implantation had a long-term positive impact on auditory and verbal development, it did not result in age appropriate reading levels in high school for the majority of students (Geers, Tobey, Moog, & Brenner, 2008).

Another important academic skill is mathematics and, as with reading, research on the mathematics achievements of children with hearing loss is generally inadequate because studies are
rare and seldom use the same measures. Furthermore, no data is available on mathematics outcomes for children educated in AVT programs. However, mathematics skill levels below that of their hearing peers are consistently reported for children with hearing loss (Kritzer, 2009). Mathematics ability for children with hearing loss has been shown to be related to children’s skills in reading, language, and morphological knowledge regarding word segmentation and meaning (Kelly & Gaustad, 2007). Two aspects of the functioning of children with hearing loss have been reported to place them at risk for underachievement in mathematics, over and above reduced access to hearing (Nunes & Moreno, 2002): 1) reduced opportunities for incidental learning and 2) difficulty in making inferences involving time sequences. Traxler (2000) found that mathematics performance of school students with hearing loss indicated only partial mastery of mathematical knowledge and skills. High school graduates were found to have computational skills comparable to 6th grade students with TH, and mathematics problem-solving skills comparable to 5th grade TH students (Traxler, 2000). Low academic attainments in mathematics, as well as reading, may have significant economic impact on the child’s future because of the relationship that exists between education level and income (Nunes & Moreno, 2002).

In addition to reading, mathematics and overall academic achievement, the way children with hearing loss perceive themselves and their abilities is an important outcome. No research on the self-esteem of children educated in AVT programs is available. Researchers have found that for children with significant hearing loss who do not develop language skills commensurate with their peers, self-esteem and emotional development are often severely affected (Bat-Chava, Martin, & Kosciw, 2005; Hintermair, 2006; Nicholas & Geers, 2003). Self-esteem measures usually take the form of either a child or parent-reported questionnaire or survey, either oral or written (e.g. Percy-Smith, Jensen, Jøsvassen, Jønsson, Andersen, Samar et al., 2006; Schorr, Roth, & Fox, 2009). In an earlier stage of this present study, a self-esteem questionnaire in which parents responded to questions regarding their child’s sense of self, sense of belonging, sense of personal power and overall self-esteem was added at the 38 months posttest. Results showed self-esteem levels that were not significantly different between groups. It was important to investigate whether these good self-esteem results would be continued as the group continued through its school life, so the self-esteem questionnaire was repeated at the 50 months posttest.

This entire study aimed to investigate the effectiveness of AVT for a group of children with hearing loss over 50 months using a battery of assessments. We studied whether the promising outcomes for speech and language for the AVT group shown in earlier stages of this longitudinal
study (Dornan et al., 2007; 2009) were maintained over 50 months by the 19 of the same children who had remained in the study for the full 50 months. Reading, mathematics and self-esteem were also investigated over the last 12 months of the study, by which time most of the two groups had reached school age. Outcomes for the AVT group were compared with those for the 19 matched TH group children over the same time period.

6.2 METHOD

This study employed a matched group repeated measures design. At the start of the study, the TH group was individually matched to the AVT group for total language, receptive vocabulary, gender and socioeconomic level as measured by the education level of the head of the household.

6.2.1 Participants

The characteristics of the AVT group can be seen in Table 6.1.
Table 6.1 Characteristics of AVT group and TH group at 50 months posttest

<table>
<thead>
<tr>
<th></th>
<th>AVT Group</th>
<th>TH Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of children</strong></td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td><strong>Mean age in years (SD)</strong></td>
<td>8.02 (1.28)</td>
<td>7.32 (1.39)</td>
</tr>
<tr>
<td>(at 50 months posttest)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Female</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Age at identification in months</strong></td>
<td>22.29 (11.82)</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Mean PTA hearing loss in better ear in dB (SD)</strong></td>
<td>79.39 (23.79)</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Onset of Loss</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congenital</td>
<td>17</td>
<td>n/a</td>
</tr>
<tr>
<td>Prelingual</td>
<td>2</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Age at CI in months (SD)</strong></td>
<td>27 (5.8)</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Time spent in AVT Program in months (SD)</strong></td>
<td>70 (16.34)</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Hearing Device:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral HA’s</td>
<td>5</td>
<td>n/a</td>
</tr>
<tr>
<td>Unilateral hearing aid</td>
<td>1</td>
<td>n/a</td>
</tr>
<tr>
<td>HA and CI in contra-lateral ears</td>
<td>6</td>
<td>n/a</td>
</tr>
<tr>
<td>Unilateral CI only</td>
<td>1</td>
<td>n/a</td>
</tr>
<tr>
<td>Bilateral CI’s</td>
<td>6</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Parents educated beyond high school</strong></td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td><strong>Occupation category of head of household</strong></td>
<td>14%</td>
<td>65%</td>
</tr>
<tr>
<td>Professional</td>
<td>43%</td>
<td>15%</td>
</tr>
<tr>
<td>Manager</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
AVT Group (AVT group).

Selection criteria for the participants were: Pure-Tone Average (PTA) at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz of ≥ 40dB hearing threshold levels in the better ear; prelingually deafened (at ≤ 18 months old); attended the educational program weekly for intensive one-to-one parent based AVT for a minimum of six months; wore hearing devices consistently (hearing aids and/or cochlear implants); aided hearing within the speech range or had received a cochlear implant; no other significant cognitive or physical disabilities reported by parents or educators; 2 to 6 years of age at the first test session; and both parents spoke only English to the child.

The children attended one of five regional centres of an AVT program in Queensland, Australia, which offers a range of services including audiology, early intervention and a cochlear implant program. This program adheres to the Principles of AVT (adapted from Pollack, 1970; endorsed by the Alexander Graham Bell Academy for Listening and Spoken Language, 2007). Even though a particular AVT program may adhere to all of the principals of AVT, programs may vary in the operational details. A description of the program in this study can be found at: [http://www.hearandsaycentre.com.au/mission-delivery.html](http://www.hearandsaycentre.com.au/mission-delivery.html) (see Appendix 4).

Of the ten original children who had left the study by the 50 months posttest, two had left the program because of diagnosis of additional disabilities, six had moved away or were unavailable, and the departure of two TH group children from the study necessitated omitting their matched AVT group pair. The participants had bilateral sensorineural hearing loss ranging from moderate to profound (mean PTA 79.39 dB HL; range = 45 dB to >110 dB). All children were fitted with hearing aids, commencing intervention within 3 months of diagnosis. Of these, 13 children received unilateral Cochlear Nucleus CI 24 implants and used an Advanced Combined Encoder (ACE) processing strategy. The median age at implant was 23.04 months (mean = 27.54 months, SD = 15.24). During the study, six of these children received a bilateral cochlear implant. All but one of the unilateral cochlear implant users in the study also wore a hearing aid in the contra-lateral ear. Both hearing devices were balanced by their Australian Hearing audiologist, according to the recommendation of Ching, Psarros and Incerti (2003). All children wore their hearing devices
consistently throughout the study. A battery of speech perception tests was administered by an audiologist to ensure that the children’s listening skills were developing optimally. The mean age of the AVT group at the start of the study was 3.80 years (S.D. = 1.15) and the mean age at the 50 month follow-up was 8.02 years (S.D. = 1.28) (Table 1).

**Typical Hearing Group (TH group).**

The TH group was recruited by families and staff of the AVT program and are described in Table 6.1.

Selection criteria for the participants were: Hearing threshold levels within the range of 0 to 20 dB at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz for both ears; normal articulation as measured by the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 2001), and using Australian norms (Kilminster & Laird, 1978); no significant cognitive or physical disabilities (as evidenced by case history or parent report); and both parents spoke only English to the child.

Sixty-four children were initially tested to ensure matching of control children with the AVT group. The TH group children who remained in the study were matched at the initial assessment with the AVT group for total language age (± 3 months) on the Preschool Language Scale (PLS-4) (Zimmerman, Steiner, & Pond, 2002) or the Clinical Evaluation of Language Fundamentals (CELF-3) (Semel, Wiig, & Secord, 1995), and also for receptive vocabulary on the PPVT-3 (Dunn & Dunn, 1997). Matching criteria also included gender and socioeconomic level, assessed by highest education level of the head of the household. The rationale for matching for language age rather than chronological age has been discussed in an earlier paper (Dornan et al., 2009). Had chronological age been used for matching (instead of language age), the children with TH generally would have had a higher language level than the children with hearing loss of the same chronological age, introducing the possibility that the children in the TH group might progress faster. Deciding how to define socioeconomic level for matching purposes was difficult because there are many different perspectives and a number of different possible measures (Kumar et al., 2008). Some factors that might have been measured include family income, education level of the parents, and parental occupation (Marschark & Spencer, 2003). It was thought that questions about family income might deter parents from long-term commitment to the longitudinal study before it had commenced. Consequently, the highest level of education of the head of the household was used. As an added check, the occupations of both groups were placed in categories according to
those developed by Jones (2003), since occupation category has been found to impact on vocabulary learning of a child with hearing loss (Hart & Risley, 1995) (see Table 6.1.). It was concluded that both AVT group and TH group parents had a moderate to high socioeconomic status.

The mean age of the TH group at the start of the study was 3.11 years (S.D. = 1.22) and the mean age at the 50 month follow-up was 7.32 years (S.D. = 1.39) (Table 1).
6.2.2 Materials

To assess total language, receptive vocabulary, speech, reading, mathematics and self-esteem at pretest and posttest for participants in both the AVT and TH groups, a battery of assessments was used (Table 6.2). As some assessments are recorded differently, (i.e. standard scores, percentile ranks and raw scores), this is also represented in the tables of results. Additional information on the assessments for reading, mathematics and self esteem is included in Appendix 2.

Table 6.2 Battery of assessments

<table>
<thead>
<tr>
<th>Test</th>
<th>Description of Test</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Language</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preschool Language Scale-Fourth Edition</td>
<td>Measures young child’s receptive and expressive language from birth to 6 years 11 months. Australian norms were not available. Used at pretest for all children but one pair. CELF-3 was used for this pair. Not used at 50 months posttest.</td>
<td>The scoring ceiling used was five consecutive items incorrect. Receptive language and oral expression were expressed as standard scores because the CELF-3 does not have age equivalents for comparison. Total language score is expressed as an age equivalent.</td>
</tr>
<tr>
<td>Clinical Evaluation of Language Fundamentals (CELF-3) (Semel, Wiig, &amp; Secord, 1995).</td>
<td>Measures child’s receptive and expressive language from 6 years to 21 months. CELF-3 used for all children at posttest. Six subtests were administered only to children who achieved higher than the top score for the PLS-4. Subtests were Sentence Structure, Word Structure, Concepts and Directions, Formulated Sentences, Word Classes and Sentence Recalling. Australian norms were not available.</td>
<td>If a child scored the highest possible score on the PLS-4, the CELF-3 was administered. Receptive language and oral expression are expressed as standard scores (age equivalents are not available) and total language is expressed as an age equivalent.</td>
</tr>
<tr>
<td>Test</td>
<td>Description of Test</td>
<td>Scoring</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Receptive Vocabulary</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peabody Picture Vocabulary Test</td>
<td>Measures child’s receptive vocabulary. Because this test was developed in the United States, Australian alternatives for some items were used by the testers: a) cupboard for closet, b) rubbish for garbage, c) biscuit for cookie, d) jug for pitcher. Australian norms were not available.</td>
<td>Child’s score is expressed as an age equivalent.</td>
</tr>
<tr>
<td>(PPVT-3) (Dunn &amp; Dunn, 1997)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Speech</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goldman-Fristoe Test of Articulation-2</td>
<td>Assesses articulation of consonants and was administered to participants in both AVT and TH groups. Australian norms were not available.</td>
<td>Child’s score is expressed as an age equivalent.</td>
</tr>
<tr>
<td>(GFTA-2) (Goldman &amp; Fristoe, 2001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reading</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading Progress Tests (RPT)</td>
<td>Stage I is used in the first 3 years of school and assesses pre-reading and early reading skills in first year of school and reading comprehension in the second and third years of school. Stage 2 is used for school years 3 – 6 and assesses outcomes for reading by assessing a range of literal and inferential skills and reading vocabulary. Australian norms were available.</td>
<td>One mark is awarded for each correct answer. No marks are awarded for multiple choice questions where more than one choice has been selected. Score is expressed as a percentile rank.</td>
</tr>
<tr>
<td>(Vincent, Crumpler, &amp; de la Mare, 1997)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>Description of Test</td>
<td>Scoring</td>
</tr>
<tr>
<td>------</td>
<td>---------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Mathematics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I Can Do Maths (Doig &amp; de Lemnos, 2000)</td>
<td>This test assesses numeracy development in first 3 years of school. Australian norms are available.</td>
<td>One mark is awarded for each correct answer. Score is expressed as a percentile rank.</td>
</tr>
<tr>
<td>Progressive Achievement Tests in Mathematics (PATMaths) (Australian Council of Educational Research, 2005)</td>
<td>This test assesses mathematic achievement levels in school years 3 to 11. Australian norms are available.</td>
<td>One mark is awarded for each correct answer. Score is expressed as a percentile rank.</td>
</tr>
<tr>
<td><strong>Self-esteem</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insight (Morris, 2003)</td>
<td>This questionnaire assesses development of self-esteem from 3 – 19 years of age (Preschool and Primary). Parents were asked to complete this questionnaire, and the 36 questions were divided into 3 different areas, which included their child’s sense of self, sense of belonging and sense of personal power. Parents were asked to report whether the skill was evident “Most of the Time” (3 points), “Quite Often” (2 points), “Occasionally” (1 point) or “Almost Never” (0 points).</td>
<td>The sum of the scores for the 3 areas studied (sense of self, sense of belonging and sense of personal power) were totalled (maximum possible score = 108) and then rated as “High”, “Good”, “Vulnerable”, or “Very Low” according to score-based criteria: “High” = 87-108; “Confident and at ease with self, other people and the world most of the time.” “Good” = 64-86; “Feels good about self, but takes knocks now and again.” “Vulnerable” = 40-63; “Tends not to feel very confident.” “Very Low” = 0-39; “Depressed or very challenging behaviour to cover this up.”</td>
</tr>
</tbody>
</table>
6.3 PROCEDURE

Appropriate ethical clearance and parent consent was obtained for this study (Dornan et al., 2007, 2009). Assessments of children in the AVT group took place at the child’s program centre. For the TH group, testing was performed either at the centre, at the child’s education setting in a quiet room, or in the child’s home. Speech, language, reading and mathematics testing was performed by experienced, qualified speech-language pathologists. Because of geographic constraints and for convenience, available qualified staff performed the testing and, frequently, different speech-language pathologists assessed the children at pretest and posttest. Tester reliability was not examined in the study, however all tests were administered according to the standardised procedures in the test manuals. Language and speech tests were administered over two or three sessions, according to the needs of each child, with rest breaks between assessments, and were discontinued if a child showed fatigue or distress. The children’s responses to the GFTA were judged as correct or incorrect at the time of testing. The order of presentation of the standardised tests used was different to that of the AVT group in order to account firstly for screening and then to establish a match with a child in the AVT group before the child was unnecessarily tested.

For the AVT group, assessments were performed in the best-aided condition. For all children with cochlear implants, the optimally functioning MAP (assessed by the child’s audiologist and Auditory-Verbal Therapist) was used for assessments. Both “T” levels (threshold, or minimum amount of current causing sound to be detected) and “C” levels (maximum amount of current causing discomfort) for the child’s MAP were measured behaviourally and confirmed objectively. Optimal implant performance was verified by stability of the MAP, consistent identification by the child of the seven sound test (i.e. the Australian adaptation of Ling’s Six Sound Test, Romanik, 1990), other speech perception tests and the cochlear implant assisted audiogram (a record of the child’s cochlear implant aided thresholds for responses at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz). The ‘Ling sounds’ are a range of speech sounds encompassing frequencies widely used clinically to verify effectiveness of hearing aid fitting in children (Agung, Purdy, & Kitamura, 2005). The Ling six sound test was developed for the North American population (Ling, 2002), and /o/ was added (seven sound test) to account for differences in production and spectral content of Australian vowels (Agung et al., 2005). For the children with hearing aids, the best-aided condition was determined by the audiologist and the Auditory-Verbal Therapist, the performance of the seven sound test, speech perception tests, and the child’s aided audiogram.

For speech and language assessments, the mean time between pretest and 50 months posttest was 51.16 months for the AVT group (SD = 1.12) and 51.37 months for the TH group (SD = 0.94),
which were not significantly different ($t = -0.335, p = 0.742$). Similarly, mean times between pretest (38 months) and posttest (50 months) for reading, mathematics and self-esteem assessments (mean = 12.73 months; SD = 2.03 for the AVT group; mean = 13.26 months; SD = 1.91 for the TH group) were also not significantly different for the two groups ($t = -1.398, p = 0.171$).

6.4 RESULTS

Preliminary analysis was carried out to ensure the validity of matching of participant groups at the pretest, that is, the matching of total language on the PLS-4 or CELF-3 and receptive vocabulary on the PPVT-3. A Mann-Whitney test showed that the overall mean language ages of the AVT ($M = 3.58$ years; $SD = 1.46$) and TH groups ($M = 3.5$ years; $SD = 1.52$) were comparable ($z = -0.307; p = 0.759$). Similarly, there were no significant differences ($z = -0.197; p = 0.844$) for mean receptive vocabulary ages at pretest on the PPVT-3 between the AVT ($M = 3.06$ years; $SD = 1.56$) and TH groups ($M = 2.97$ years; $SD = 1.46$). Overall, both groups were found matched for total language age and receptive vocabulary at the pretest.

6.4.1 Speech and Language

Table 6.3 displays the pretest and posttest mean age equivalents, standard deviations, $z$ and $p$ values for total language, receptive vocabulary and speech for the 19 children in the AVT and TH groups at pretest and at the 50 months posttest.
Table 6.3 Mean age equivalents (in years), standard deviations (in parentheses), z and p values for total language, receptive vocabulary and speech for the 19 children in the AVT and TH groups at pretest and at 50 months posttest

<table>
<thead>
<tr>
<th>Name of Test</th>
<th>Group</th>
<th>Pretest Mean Age Equivalent (SD)</th>
<th>Posttest Mean Age Equivalent (SD)</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLS-4/CELF-3</td>
<td>AVT</td>
<td>3.58 (1.47)</td>
<td>7.86 (2.88)</td>
<td>-3.824</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>3.5 (1.52)</td>
<td>8.17 (1.03)</td>
<td>-3.825</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td>1.550</td>
<td></td>
<td>0.121</td>
<td></td>
</tr>
<tr>
<td>Comparison</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPVT-3</td>
<td>AVT</td>
<td>3.06 (1.55)</td>
<td>7.83 (3.66)</td>
<td>-3.824</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>2.96 (1.46)</td>
<td>8.33 (1.58)</td>
<td>-3.825</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td>2.921</td>
<td></td>
<td>0.235</td>
<td></td>
</tr>
<tr>
<td>Comparison</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GFTA-2</td>
<td>AVT</td>
<td>3.06 (1.49)</td>
<td>6.70 (1.31)</td>
<td>-3.824</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>3.51 (1.42)</td>
<td>7.17 (0.98)</td>
<td>-3.765</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td>0.336</td>
<td></td>
<td>0.737</td>
<td></td>
</tr>
<tr>
<td>Comparison</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: * Acceptable level of significance = ≤0.05; Progress with time for each group analysed using the Wilcoxon Signed Rank Test; Between group comparisons of progress analysed using the Mann-Whitney Test.

Note 2: AVT group chronological age at pretest was 3.8 years (SD = 1.15) and at posttest was 8.02 years (SD = 1.27). TH group chronological age at pretest was 3.11 years (SD = 1.22) and at posttest was 7.32 years (SD = 1.39).

For total language age, assessed using the PLS-4 or CELF-3, both groups made significant progress over 50 months, and the change in scores over this period of time was not significantly different between the groups. Further comparisons of receptive and expressive language results were made using standard scores on the CELF-3, as age equivalence is not calculated on this
For receptive language, no significant changes in standard scores were found from pretest (standard score = 95, SD = 17.47) to posttest (standard score = 102.26, SD = 19.44) for each group because standard scores are age corrected ($z = -1.808$, $p = 0.071$ for the AVT group; $z = -1.7$, $p = 0.089$ for the TH group). Also, the amount of change displayed by both groups was not significantly different ($z = 0.599$, $p = 0.549$). Similarly, for expressive language, there was no significant change in standard scores between pretest (standard score = 92.95, SD = 13.86) to posttest (standard score = 98.26, SD = 20.57) for each group ($z = -1.002$, $p = 0.316$ for the AVT group; $z = -1.373$, $p = 0.170$ for the TH group), and no significant difference for amount of progress between the two groups ($z = -1.131$, $p = 0.895$).

### 6.4.2 Receptive Vocabulary

For receptive vocabulary as assessed using the PPVT-3, both groups showed significant changes in age equivalents over the 50 months, with no significant difference in the amount of change between the groups (Table 6.3). The mean age equivalent for the AVT group was within the typical range for their chronological age.

### 6.4.3 Speech

On the GFTA-2, significant increases in age equivalents were evident for both groups over 50 months, with no significant differences in the changes between the two groups (Table 6.3). At the 50 months posttest, 42% of the AVT group and 63% of the TH group scored at the ceiling of 7 years 8 months on this test.

### 6.4.4 Reading and Mathematics

Table 6.4 shows the Pretest and Posttest percentile ranks for reading and mathematics for the 7 pairs of eligible children in the AVT group and TH group at 38 and at the 50 months posttest.
For these assessments, a smaller sample of 7 pairs of children in each group was available for comparison. This is because a number of children in both groups had not yet entered school or begun formal reading and mathematics by the 50 months posttest (1 AVT group child; 3 TH group children) or had not reached this stage by the 38 months posttest (4 AVT group children; 13 TH group children).

The numbers of children in each group were considered too small for statistical comparison. For reading, the AVT group scores were at the 83rd percentile at the 38 months posttest at the 88th percentile at the 50 months posttest. Similarly, for mathematics, the AVT group scores were at the 60th percentile at the 38 months posttest, and at the 78th percentile at the 50 months posttest. The percentile ranks at the 50 months posttest for both groups were comparable (see Table 6.4).

### 6.4.5 Self-esteem

Eighteen parents of the AVT group and 16 parents of the TH group responded to the self-esteem questionnaire at the 50 months posttest, and 10 matched pairs were identified with scores both at the 38 months posttest and the 50 months posttest. Table 6.5 shows the results for sense of self, sense of belonging, and sense of personal power subscales for both groups at 50 months, the highest possible score being 36 in each category.

<table>
<thead>
<tr>
<th>Name of Test</th>
<th>Group</th>
<th>N</th>
<th>Pretest</th>
<th>Range</th>
<th>N</th>
<th>Posttest</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Percentile Rank</td>
<td></td>
<td></td>
<td>Percentile Rank</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(SD)</td>
<td></td>
<td></td>
<td>(SD)</td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>AVT</td>
<td>7</td>
<td>83.57 (17.74)</td>
<td>51-98</td>
<td>7</td>
<td>88.14 (10.90)</td>
<td>46-99</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>7</td>
<td>88.14 (7.90)</td>
<td>75-98</td>
<td>7</td>
<td>90.14 (9.81)</td>
<td>79-99</td>
</tr>
<tr>
<td>Mathematics</td>
<td>AVT</td>
<td>7</td>
<td>60.43 (35.02)</td>
<td>23-98</td>
<td>7</td>
<td>77.57 (28.54)</td>
<td>32-99</td>
</tr>
<tr>
<td></td>
<td>TH</td>
<td>7</td>
<td>81.28 (24.88)</td>
<td>67-96</td>
<td>7</td>
<td>80.86 (19.35)</td>
<td>77-92</td>
</tr>
</tbody>
</table>
Table 6.5 Raw scores for self-esteem for AVT group and TH group for Primary Insight at 38 and 50 months posttests

<table>
<thead>
<tr>
<th></th>
<th>Sense of Self (SD)</th>
<th>Sense of Belonging (SD)</th>
<th>Sense of Personal Power (SD)</th>
<th>TOTAL Self-esteem (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>Mean</strong></td>
<td><strong>Mean</strong></td>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td></td>
<td><strong>38 months</strong></td>
<td><strong>50 months</strong></td>
<td><strong>38 months</strong></td>
<td><strong>50 months</strong></td>
</tr>
<tr>
<td>AVT Group</td>
<td>31.07 (3.93)</td>
<td>32.1 (3.11)</td>
<td>31.64 (2.98)</td>
<td>32.4 (3.09)</td>
</tr>
<tr>
<td>TH Group</td>
<td>31.93 (4.8)</td>
<td>32.94 (2.81)</td>
<td>29.92 (5.27)</td>
<td>33.8 (2.53)</td>
</tr>
<tr>
<td>Group Comparison</td>
<td><strong>z</strong></td>
<td><strong>-0.324</strong></td>
<td><strong>-0.609</strong></td>
<td><strong>-0.949</strong></td>
</tr>
<tr>
<td></td>
<td><strong>p</strong></td>
<td><strong>0.746</strong></td>
<td><strong>0.542</strong></td>
<td><strong>0.343</strong></td>
</tr>
</tbody>
</table>

Acceptable level of significance = ≤0.05; Progress with time for each group analysed using the Wilcoxon Signed Rank Test; Between group comparisons of progress analysed using the Mann-Whitney Test.
Mann-Whitney tests showed no significant differences between the groups for sense of self, sense of belonging and sense of personal power components of the questionnaire. Furthermore, at the 50 months posttest, the total self-esteem scores between the two groups were not significantly different. The majority of children in both participant groups (80% in the AVT group and 70% in the TH group) were rated as having “high” self-esteem while the remainder had “good” self-esteem. No children from either group were rated in the “vulnerable” or “very low” categories.

6.5 DISCUSSION

This study reported speech perception outcomes for the AVT group from the 38 months to the 50 months posttest and also compared outcomes for the AVT group for receptive, expressive and total language, receptive vocabulary and speech over 50 months with those for the TH group. In addition, the study also compared reading, mathematics and self-esteem outcomes between the AVT and TH groups over the last 12 months of the study. The promising earlier outcomes for the AVT group that indicate typical rate of progress for total language and speech skills to those of hearing controls (Dornan et al., 2007, 2009) have been maintained over the 50 months. Furthermore, rate of receptive vocabulary progress, reported for the AVT group as being less than for the TH group at earlier posttests (Dornan et al., 2009), was found to have accelerated so that the rate of progress was the same as for the TH group at the 50 months posttest. Since percentile ranks are already normalized scores, the improvement in percentile ranks for the AVT group indicates that the children were progressing at a faster than typical rate. Self-esteem levels were not significantly different between the groups, with predominantly high self-esteem reported for both groups. These results are now discussed and compared with previous research.

Total language growth for the AVT group was at a rate of 12.31 months per year, comparing favourably to a rate of 13.45 months for the TH group. The majority of the AVT group (78.95%) and all of the TH group scored within the typical range or above for language at the 50 months posttest. Four AVT group children scored within one standard deviation below the typical range. The AVT group achieved mean total language scores that were 2.1 months less than their mean chronological age, or within one standard deviation of the mean for their age. The only other studies that have reported such positive language growth results have included children fitted with hearing aids at less than 6 months of age (Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998) or children receiving cochlear implants before 18 months of age (Ching, Dillon, Day, Crowe, Close, Chisolm, & Hopkins, 2009; Dettman, Pinder, Briggs, Dowell, & Leigh, 2007; Svirsky, Teoh, & Neuburger, 2004). In the present study, one child had been fitted with hearing aids before 6 months and two
children had been fitted with cochlear implants at less than 18 months. Nevertheless, the group as a whole achieved age appropriate language.

These positive results for language for the AVT group are similar to those obtained previously for children in AVT programs (e.g. Rhoades, 2001; Rhoades & Chisolm, 2000) in which the majority of children were reported to show no significant chronological age and language age gap when entering mainstream school. Results obtained here are superior to a number of other studies of children with hearing loss educated using a range of different interventions (e.g. Blamey, Barry et al., 2001; Geers, Nicholas, & Sedey, 2003; Sarant, Holt, Dowell, Rickards, & Blamey, 2008).

The AVT group progressed in receptive vocabulary development at a rate of 13.73 months per year over the 50 months of the study, compared to the TH group at 15.46 months, with no significant difference in progress between the two groups. For the AVT group, 68% had scores within the typical range or above for receptive vocabulary (and the remainder were within one standard deviation below the mean), compared to 100% of the TH group. At the 50 months posttest, the gap between chronological age and age equivalent for the AVT group for receptive vocabulary was 2.4 months. This suggests that the AVT group were functioning as expected for their age for receptive vocabulary. The receptive vocabulary results for the AVT group are superior to those found in the literature, which have reported levels of receptive vocabulary for children with hearing loss lower than children with typical hearing (e.g. Blamey, Sarant et al., 2001; Eisenberg, Kirk, Martinez, Ying, & Miyamoto, 2004; Fagan & Pisoni, 2010; Hayes, Geers, Treiman, & Moog, 2009; Schorr, Roth, & Fox, 2008; Uziel et al., 2007).

Similarly to earlier stages of the study, the AVT group achieved intelligible speech, with the mean scores as the TH group (Dorman et al., 2007, 2009). Only one child had scores which were below the age appropriate range. The rate of change in scores per year for correct articulation of consonants in words by the AVT group was 10.48 months per year and 10.53 months for the TH group. The lack of a significant difference between the changes in speech scores for the AVT and TH groups is surprising, because children with hearing loss typically have difficulty with articulation of speech sounds (Marschark, Lang, & Albertini, 2002; Schorr, Roth, & Fox, 2008, Uziel et al., 2007). An increase in accuracy of consonant production for children with implants (like most of the AVT group in this study) has been reported, and increasing ability with longer implant experience and use of oral communication (Tobey, Geers, Brenner, Altuna, & Gabbert, 2003). A high correlation between speech perception and speech production has also been reported for
children with cochlear implants (Phillips, Hassanzadeh, Kosaner, Martin, Deibl, & Anderson, 2009). It is likely that the combination of cochlear implant use and AVT may have positively influenced the level of speech skills achieved by the AVT group in this study.

In this paper we report preliminary results for reading and mathematics over a 12-month period for a small sample of children (n = 7). Over the 12 months of the study, the AVT group results for reading improved from the 84th percentile to the 88th percentile (as compared to from the 88 percentile to the 90 percentile for the TH group). The mean AVT group results for mathematics improved from the 60th percentile to the 78th percentile (as compared with remaining around the 81 percentile for the TH group). However the range of standard scores was wide, particularly for the AVT group (69-90 for reading for the AVT group and 79-99 for reading for the TH group; 29-99 for mathematics for the AVT group and 45-96 for mathematics for the TH group). Since the mathematics assessments used relied on reading for the presentation of the test, this improvement in mathematics might also be reflected by the progress made by the AVT group in language and in reading ability. Since percentile ranks are already normalized scores, the improvement in percentile ranks for the AVT group indicates that the children were progressing at a faster than typical rate. These good results for reading and mathematics, although for a very small group, show the potential for this group of children to be educated in the mainstream. As the AVT group were relatively young (8.02 years) at the 50 months posttest, it will be important to follow up this study, particularly for reading over a longer term, especially as it has been found that reading scores for a group of 85 adolescents with cochlear implants studied from ages 8-9 years did not keep pace with their language development at ages 15-18 years (Geers, Tobey, Moog, & Brenner, 2008). In addition, further large-scale studies are needed to investigate reading progress for children in AVT programs. Positive reading achievement for children with hearing loss educated using AVT has been reported in a number of studies (Durieux-Smith et al., 1998; Goldberg & Flexer, 1993; 2001; Robertson & Flexer, 1993; Wray, Flexer, & Vaccaro, 1997), and has been related to speech perception and speech production performance (Spencer & Oleson, 2008). Together, these findings are in contrast to unfavourable reports on reading ability for children with hearing loss in some studies (e.g. Boothroyd & Boothroyd-Turner, 2002; Moeller, Tomblin, Yoshinaga-Itano, Connor, & Jerger, 2007; Traxler, 2000; Vermeulen, van Bon, Schreuder, Knoors, & Snik, 2007). The good levels of speech perception and speech production achieved by the AVT group in this research (Dorman et al., 2009) may have had an influence on their reading achievement. The addition of an assessment of phonological processing in future research may add to the information on reading skills for children in AVT programs.
In relation to mathematics, the same inherent problems of sample size made interpretation of the results difficult. At the 50 months posttest, however, the mean percentile rank for the AVT group for mathematics was high (78th percentile), as was the percentile rank for the TH group (81st percentile), which suggests that the results are relatively comparable for both groups. Since the mathematics assessment was both read by the AVT group and presented to them verbally, these outcomes represented positive skill levels for listening and reading as well as mathematics for this group. The current AVT group performed better than the group studied by Traxler (2000), who found that the mathematics ability of high school students with hearing loss was at a “basic level” or below. The findings for the AVT group may be explained by their good reading and language skills, as Kelly and Gaustad, (2007) found that levels of reading and language skills influenced the ability of a child with hearing loss to achieve in mathematics. As well, the good listening ability of the AVT group may well have influenced their mathematics ability, as their listening ability allowed them opportunities for incidental learning of early mathematics concepts, unlike the study reported by Nunes and Moreno (2002). More studies are needed on mathematics outcomes for children with hearing loss to add to the body of knowledge in this area.

The self-esteem results for the AVT group are better than those obtained by a number of other researchers who report adversely affected self-esteem (Nicholas & Geers, 2003), mental health (Laurenzi & Monteiro, 1997), and socio-emotional development (Prizant & Meyer, 1993) for children with significant hearing loss. In the present study, there was no significant difference between the AVT group and the TH group for self-esteem. These results are in agreement with those in a Danish parent survey of children with hearing loss (Percy-Smith, Jensen, Josvassen, Jønsson, Andersen, Samar et al., 2006), which reported a satisfactory or very satisfactory level of well-being for children with cochlear implants. The AVT group results are also in agreement with those of Schorr, Roth and Fox (2009) who found that 37 children (aged 5-14 years) who received a cochlear implant and used spoken language reported improved quality of life; positive self-esteem was also related to younger age of cochlear implant. The high results for self-esteem for the AVT group could be a result of their good use of their hearing device, their good listening skills and speech and language development, but their mean age of cochlear implantation was not particularly early (27 months). It is significant that these results for self-esteem were based on parent rating, showing that the parents perceived that there was little detrimental impact on the childrens’ self-esteem from the hearing loss at the 50 months posttest.
Although the study findings are promising, the outcomes cannot be generalised, for a number of reasons. Firstly, both the AVT and TH groups were mainly drawn from a moderate to high socioeconomic level. This may have caused a self-selection of both groups of children, making some interpretation difficult. Similarly, a number of studies on outcomes of AVT have reported the predominance of well-educated parents (Dorman et al., 2007, 2009; Easterbrooks, O’Rourke, and Todd, 2000; Rhoades & Chisolm, 2000). Socioeconomic status has been found to be a significant predictor of better speech perception performance for children with hearing loss (Hodges, Dolan Ash, Balkany, Schloffman, & Butts, 1999), and has also been associated with better language for children with TH (Hart & Risley, 1995; Hoff-Ginsberg, 1991). Higher socioeconomic levels have been found to be associated with higher reading and writing scores and a lower risk of academic delays (Geers, 2003; Martineau, Lamarche, Marcoux, & Bernard, 2001). Low socioeconomic status has been reported as being associated with reduced academic opportunity and underachievement (Connor & Zwolan, 2004). Therefore it is suggested that if only children from high socioeconomic groups attended an education program, better outcomes for speech perception, language, reading and writing would possibly result. As AVT is becoming more available to diverse family groups, the limitations of the generalisability of outcomes of this study must be acknowledged. Another limitation of this research is the fact that even though one child with mild cerebral palsy was included, two children had left the program in the first 9 months of the study because of additional disabilities being diagnosed. It is acknowledged that the outcomes for the AVT group may not be applicable to the growing cohort of children with disabilities in those newly diagnosed today with hearing loss through newborn hearing screening (Larroque et al., 2008). In addition, similar comments are applicable to the generalisability of outcomes data for children who are not native English speakers, which is another growing demographic group in the population of children with hearing loss.

Whether AVT is effective for children from families across a wide socioeconomic range remains an important empirical question for future research. A further study limitation includes the relatively small numbers of participants, particularly for reading and mathematics comparisons. Despite these limitations, the research goes some way towards providing a benchmark for minimum rate of progress with treatment for children with hearing loss.

6.6 SUMMARY

The results described here provide evidence that AVT has been an effective intervention option for that group. Speech perception has improved significantly with moderate to high levels at
50 months after the start of the study. Although the group was identified at a mean age of 22.29 months, much later than the current “international gold standard” of 6 months of age (Joint Committee on Infant Hearing, 2007; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998), their language and speech attainments have been the same as a matched control group of children with typical hearing, the TH group, over a 50 month time period. Reading, mathematics and self-esteem outcomes were also comparable for both groups over the last 12 months of the study period. This study has provided a research model, utilizing a control group matched for language age, which could also be replicated across different languages, cultures and countries and with different education approaches.
6.7 REFERENCES


CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

This chapter of the thesis summarizes the main findings of the study, including related research, and discusses how the original aims were fulfilled. This is followed by the clinical implications of the findings. The significance of the study and limitations to the research outcomes are then discussed, and suggestions made for future research directions.

7.1 SUMMARY

This thesis aimed to measure the outcomes for a group of children in an AVT program, compared with outcomes for the TH group through a longitudinal study over 50 months (Chapter 1, Section 1.7, p.12). This study has found that the AVT group was able to achieve significant progress in speech perception, with high levels of ability for live voice and moderate to high levels for recorded voice speech perception at the 50 months posttest. Speech perception was not measured for the TH group. In addition, the AVT group made significant progress in language, receptive vocabulary and speech skills. Furthermore, over 50 months, their rates of development for language and speech skills were not significantly different to those of the TH group. There were some differences in rates of development of receptive vocabulary at the 21 months and 38 months posttests, with the TH group showing significantly greater changes in scores to the AVT group. However, by the end of the study period, there was no significant difference between the changes in scores for the two groups for receptive vocabulary from the pretest to the 50 months posttest. Preliminary investigations of reading and mathematics abilities over the last 12 months of the 50 months study showed that the scores were comparable between the two groups; numbers were too few to allow statistical analysis. Nevertheless, the mean percentile ranks for the scores for the AVT group were high, and within the typical range. Furthermore, there was no significant difference between the self-esteem outcomes for the AVT group and the TH group both at the 38 months and 50 months posttests.
Chapter 1 defined hearing loss and described the impact of hearing loss on a young child, and the treatment options for hearing loss. Chapter 2 reported on a review of the research literature relating to speech and language outcomes for children with hearing loss educated in AVT programs and compared this evidence to available research for outcomes associated with other types of educational approaches. This review highlighted the lack of research investigating outcomes for children educated in AVT programs, the limitations of the available research, and the need for further studies (Dornan, Hickson, Murdoch, & Houston, 2008).

Chapter 3 described the research model that was developed for this study, the characteristics of the AVT group and the rationale for individually matching them with the TH group (Dornan, Hickson, Murdoch, & Houston, 2007). This chapter presented outcomes for the AVT and TH groups (n = 29 in each group), who were tested on a battery of assessments at baseline (pretest) and at the 9 months posttest. This study was planned as a pilot program for the remainder of the longitudinal study. It was demonstrated that the research model was clinically feasible and provided useful outcomes.

Results showed that both groups made significant progress. There were no significant differences in the changes in scores from the pretest to the 9 months posttest for receptive, expressive and total language, receptive vocabulary and speech skills (articulation of consonant sounds in words). At this posttest, 72% of the AVT group had scores that fell within the typical range or above for total language, 69% for receptive vocabulary, and 62% for speech skills. Findings from this pilot study provided a foundation for later stages of the study, in which the time span for testing was extended, and other assessments were added as appropriate for the age and stage of speech and language development of the participants.

Chapter 4 reported the results for 25 of the same pairs of children who remained in the study from the pretest to the 21 month posttest (Dornan, Hickson, Murdoch, & Houston, 2009). Using the same test battery as in Chapter 3, the outcomes for the AVT group were compared for both groups of children from the pretest to the 21 months posttest. Two additional measures were reported for the AVT group over this time span: speech perception and speech intelligibility for consonant sounds in spontaneous discourse.

Significant progress was made by the AVT group for speech perception of live voice but not recorded stimuli. Similarly, significant progress was also made for receptive, expressive and total
language and speech skills (articulation of consonant sounds in words), with the changes in scores between both groups not significantly different. However, the TH group achieved significantly greater progress for receptive vocabulary. Nonetheless the mean score for the AVT group was within the typical range. Speech skills for consonant sound production in spontaneous discourse progressed significantly, especially for later emerging consonants, and these were developing in a similar pattern to children with TH. At this posttest, 84% of the AVT group had scores that fell within the typical range or above for total language, 69% for receptive vocabulary, and 65% for speech skills. These two earlier stages of the study reported in Chapter 3 (pretest to 9 months) and Chapter 4 (pretest to 21 months) consolidated the research model, and allowed for the continuation of this study to the next point of assessment, 38 months after the pretest.

Chapter 5 reported the outcomes for the AVT and TH groups at the 38 months posttest for 23 of the same pairs of children who had continued in the study to this point. The test battery included the same tests previously used, except for the measurement of consonant sounds in spontaneous discourse for the AVT group, which was not continued because of the time-consuming phonetic transcriptions needed as the children’s spoken language continued to develop. Speech perception was also investigated for the AVT group from the 21 months posttest to the 38 months posttest. In addition, assessments of reading, mathematics and self-esteem were added for both groups at the 38 month posttest, as many of the children had reached school age.

Whereas previously the AVT group scores for speech perception with recorded stimuli did not show significant progress, results at the 38 months posttest did show significant progress. Also both groups showed significant progress for total language, receptive vocabulary and speech skills over the 38 month study period. Receptive and expressive language was measured in standard scores at this stage because of the fact that most children were tested on the CELF-3, which does not have age equivalents for these measures. Therefore, significant improvement was unable to be demonstrated as standard scores are age corrected. There were no significant differences in progress scores between the AVT and TH groups for total language and speech skills from the pretest to the 38 months posttest. However, the TH group showed significantly higher changes in scores for receptive vocabulary from the pretest to the 38 months posttest. Nevertheless, the mean age equivalent for the AVT group fell within the typical range for their mean age. At this posttest, 71% of the AVT group had scores that fell within the typical range or above for total language, 70% for receptive vocabulary, and 71% for speech skills. Reading and mathematics scores for both AVT and TH groups showed no significant differences between the groups, but only 13 pairs of children for
whom both in the pair had entered school and completed the tests were available at the 38 months posttest. No significant differences were found for self-esteem scores between the groups. The addition of tests for reading, mathematics and self-esteem at the 38 months posttest provided a baseline for these for both groups for the final stage of the study at the 50 months posttest.

Chapter 6 reported on the results of the final study in the thesis. This investigated the outcomes for 19 pairs of the same children who remained in the study over 50 months (Dornan, Hickson, Murdock, & Houston, 2010). Speech perception for the AVT group, and also language and speech skills (production of consonants in words) for both the AVT and TH groups were reported. At this stage, speech perception measures for live voice were not reported as scores for the AVT group were already high and stable; recorded voice measures were investigated from the 38 months posttest to the 50 months posttest. In addition, reading, mathematics and self-esteem were also measured for both groups from the 38 months posttest to the 50 months posttest.

The results at the 50 months posttest were in agreement with earlier stages of the study, and showed that both groups made significant progress in development of total language, receptive vocabulary and speech skills. Similarly to the 38 months posttest, age equivalent scores for receptive and expressive language were not available. There were no significant differences in the changes in scores for total language, receptive vocabulary and speech skills between the AVT group and the TH group from the pretest to the 50 months posttest. At this stage, the rate of progress for receptive vocabulary for the AVT group, which was below that of the TH group at the 21 months and 38 months posttests, was no longer significantly below that of the TH group. At this posttest, 79% of the AVT group had scores that fell within the typical range or above for total language, 68% for receptive vocabulary, and 84% for speech skills. For the AVT group, positive speech perception scores for recorded voice showed a moderate-to-high level of attainment at the 50 months posttest, and no further significant progress was found for recorded voice scores over the 12 months period from the 38 months posttest to the 50 months posttest. Preliminary results for reading and mathematics from the 38 months posttest to the 50 months posttest showed that, as the numbers of pairs of children completing both the pretest at 38 months and the posttest at 50 months were very small (n = 7), no statistical analysis was possible. However, the rate of progress and the final level of reading and mathematics skills were comparable between the two groups. Self-esteem scores at the 38 months and 50 months posttests were not significantly different between the AVT and TH groups.
The overall results for the AVT group for language are consistent with those of other researchers for children in AVT programs (Hogan, Stokes, White, Tyszkiewicz, & Woolgar, 2008; Rhoades, 2001; Rhoades & Chisolm, 2000). These have reported a minimum rate of language progress of 12 months over a 12 months time period, the same as for the AVT group. The results for the AVT group are in contrast with the slower rates of development found by some other researchers for children of a similar level of hearing loss using a different education approach (e.g. Blamey, Barry et al., 2001). A rate of language development the same as TH children, as found here, is usually reported for children identified and receiving intervention before 6 months of age (Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998) or for children receiving a cochlear implant before 18 months of age (Ching et al., 2009; Colletti, 2009; Dettman, Pinder, Briggs, Dowell, & Leigh, 2007; Svirsky, Teoh, & Neuburger, 2004). The AVT group were not identified early (mean age = 22.29 months) nor did they, as a group, receive their cochlear implants early (mean age = 27 months), indicating that factors other than these may have been producing the good language results for the AVT group.

The significant speech and language progress made by the children in the present study is in line with a number of recent studies that reveal the neural development potential of children with hearing loss. The results for the AVT group are in agreement with research that shows that the atypical re-organization of the auditory nervous system that occurs in children who are congenitally deaf can be altered through auditory brain access with appropriate amplification within the optimal development period of the auditory brain (Gilley, Sharma, & Dorman, 2008). The AVT group results show that the auditory brain can be developed through intensive spoken language input, so that listening and speaking like children with TH is possible (Dornan, Hickson, Murdoch, Houston, & Constantinescu, 2009, 2010). Furthermore, these results have demonstrated the potential for this auditory neural development to take place at the same rate as for children with TH of the same initial language age.

These results are also consistent with research showing that the auditory cortical cells of young typically hearing macaque monkeys exhibited “exuberant growth” for many months after the visual cortical cells had ceased growing, indicating great potential for extended growth and wiring of auditory brain areas (Elston, Okamoto, Oga, Dornan, & Fujita, 2010). It is suggested that this group of children educated using AVT, which focuses on listening and developing auditory skills, has demonstrated this exuberant growth of their auditory cortex to such an extent that they have achieved good listening and spoken language development.
The AVT group results are also in line with neuroscience research showing the benefits of enriched auditory environments, which have been found to produce physiological changes in the brains of experimental rats (Engineer et al., 2004). These physiological changes were found to include activation of an increased number of auditory neurons, improved neural response strength and threshold sensitivity (better response to soft sounds), and alterations to the latency of auditory cortex neurons. AVT actively promotes auditory brain development through enriched auditory environments, causing continual re-firing of auditory brain pathways (Cole & Flexer, 2008). Hart and Risley (1995) have found that children learn language most effectively through a profusion of auditory input from parents and caregivers. Repeated auditory stimulation leads not only to stronger auditory neural connections, but also to maturation of auditory brain pathways that is highly dependent on auditory experience (experience dependent plasticity) (Engineer et al., 2004; Moucha & Kilgard, 2006). As auditory brain maturation is a precondition for the development of listening and spoken language (Cole & Flexer, 2008), this brain maturation has been demonstrated by the AVT groups outcomes.

This study has fulfilled its aims by measuring the outcomes of an AVT program for children with hearing loss, compared with outcomes for a matched group of children with TH through a longitudinal study. A research model has been developed which has been shown to be clinically viable, and useful for measuring the outcomes of an education program. This study has contributed Class 11 evidence towards the outcomes of AVT, the highest level of evidence possible in this type of research as was discussed in Chapter 2, Section 2.4, p.21. The study participants have been described at every stage of the study, and the intervention described in detail at http://www.hearandsaycentre.com.au/mission-delivery.html (see Appendix 4). An extensive battery of assessments has been used covering a wide number of domains, and a control group included, which was also discussed in Chapter 2 as being desirable as part of a robust research model. Because of the inclusion of this matched control group, the research model developed has potential application to other populations of children with hearing loss. For example, the language outcomes of a group of children educated in an auditory-oral program could be compared over time to a group of children with TH, matched according to the same parameters used in this research. The study has also provided positive evidence towards setting a benchmark for developmental progress for language of 12 months in 12 months of time. The study will contribute to the body of available research evidence for potential rate of language development for children with hearing loss, which will allow for comparison of progress for individual or groups of children with this benchmark.
7.2 IMPLICATIONS FOR IDENTIFICATION, DIAGNOSIS AND INTERVENTION

Current recommendations for newborns include identification, diagnosis and commencement of intervention by 6 months of age for optimal spoken language development (Ching et al., 2009; Joint Committee on Infant Hearing, 2007; Nelson, Bougatsos, & Nygren, 2008). However, this study has demonstrated good speech and language potential for children educated in an AVT program, the majority (79%) of whom had total language within the typical range or above at the 50 months posttest (as compared to 55% at the pretest), and were not diagnosed early by the current newborn hearing screening standards. The results showed that the majority, who were diagnosed at 22.29 years of age and enrolled in an AVT program, were able to make speech and language progress similar to children with TH. However, the variability for the AVT group was wider than for the TH group, indicating that not all children were able to make the same amount of progress as their matched pair in the TH group. The relatively small sample size that was retained after 50 months means that the generalization of the results to other types of population samples is limited. This study provides information to parents of children who have not received newborn hearing screening or who have developed a hearing loss in the 2 years following birth. Positive opportunities for developing intelligible speech and language similar to peers with typical hearing are the potential through the use of AVT. The question now remains whether AVT can offer children identified at birth through newborn hearing screening, the same or better positive potential for speech and language development.

One clinical implication of these results for the AVT group is that receptive vocabulary, which has been shown to be progressing at a slower rate than the TH group at the 21 months posttest (Chapter 4) and the 38 months posttest (Chapter 5), may need to be a focus for intervention to ensure that development of this skill is consistent with overall total language progress. Additional effort on behalf of the professionals and parents in facilitating growth of receptive vocabulary may be beneficial in accelerating its trajectory of development, which could potentially assist in later language and reading skills development.

Although the study does not show that AVT is superior to any other education approach, it does provide evidence about the potential benefits for children using an AVT approach and enrolled around 2 years of age in a similar program as the one studied.
In an AVT program, parents receive simultaneous education with their child with hearing loss (Alexander Graham Bell Academy of Listening and Spoken Language, 2007), with high levels of parent involvement being an inherent principle of AVT. Parent involvement has been found to be an important predictor of young children’s speech and language progress (DesJardin & Eisenberg, 2007; Niparko et al, 2010), particularly in an AVT program (Wu & Brown, 2004). One implication of the study is that, in agreement with Wu and Brown, a focus on ongoing education and motivation of parents in collaborative partnerships with professionals is important for children with hearing loss to achieve their speech and language potential. It is acknowledged that, as Young and Killen (2002) note, some language gaps may still exist in the presence of near-typical assessment outcomes. Nevertheless, the clinical implications of this study are that language, receptive vocabulary and speech outcomes similar to those for children with TH are possible for children with hearing loss educated in an AVT program.

This study is significant because outcomes studies for children with hearing loss are essential for measuring the significant impact of hearing loss, and for investigating how the negative impact of hearing loss may be ameliorated by intervention (as described in Chapter 1). Outcomes studies are also important because parents of children newly diagnosed with hearing loss have the right to high level (Class 11) research evidence (see Chapter 2). This is critical to guide them in making education choices that produce the outcomes they hope for with respect to their child. Such studies are also important for informing professionals who work with children with hearing loss, and governments and policy makers who provide services for these children.

This research is also significant because it suggests a benchmark of a minimum of one year of progress in one year of time for rate of language development for children with hearing loss, which is more robust than evidence for a similar benchmark suggested by previous authors, (see Chapter 2) (e.g. Easterbrooks, 1987; Hogan, Stokes, White, Tyszkiewicz, & Woolgar, 2008; Rhoades & Chisolm, 2000).

7.3 LIMITATIONS OF STUDY

The limitations of this study have been discussed in more detail in Chapter 6 and are summarized here. These limitations include the possibility of self selected nature of the AVT group and the TH group because of the fact that both groups were from families of moderate to high socioeconomic level, and also because two children left the study in the first 9 months because they
were diagnosed with additional disabilities to their hearing loss. Other limitations of the study include the small numbers of participants, particularly at the later stages of the research for reading and mathematics. Also, reading, mathematics and self-esteem were measured only over a short time period of 12 months. Therefore, more children from a range of socioeconomic backgrounds need to be evaluated over longer time span with a comprehensive battery of speech, language and educational assessments in order for the findings of this study to be validated. It is not possible to generalize the findings of this study to the heterogeneous population of children with hearing loss.

7.4 FUTURE DIRECTIONS

Suggestions for future research include the need for larger numbers of participants than in the AVT group examined here, and the inclusion of participants from lower socioeconomic backgrounds and/or with additional disabilities. Whether AVT is effective across a broader range of families is an important question for future research. Extension of the time period for the study to further investigate the development of reading and mathematics, as the content of the school syllabus becomes more difficult, would also be valuable. The inclusion of additional measures of maternal (as well as head of the household) socioeconomic level, parental involvement, and the children’s phonological processing would also provide additional information on the outcomes of AVT and factors that influence outcomes. In addition, a similar longitudinal controlled study of AVT outcomes which includes suitable assessments for investigating listening and spoken language outcomes for babies identified at, or shortly after, birth is critical.

Finally, as the research model in this study has applicability to other populations of children in AVT programs and alternative education approaches across different languages, cultures and countries (because the control group could be conscripted from similar populations) the study should be replicated with other groups of children with hearing loss. Furthermore, the benchmark for developmental progress for language established here may allow for comparison of progress for individual children or a group of children in future studies.

7.5 CONCLUSIONS

There were no significant differences between the AVT and TH groups for the changes in scores for total language and speech from the pretest to the 50 months posttest. Even though the TH group showed significantly higher changes in scores for receptive vocabulary than the AVT group
from the pretest to the 21 months and 38 months posttests, there was no significant difference in overall change in scores for this skill from the pretest to the 50 months posttest. Furthermore, even though the scores for the AVT and TH groups for reading and mathematics over the last 12 months of the 50 months study were too few for statistical analysis, the scores were comparable between the AVT and TH groups. In addition, there were also no significant differences in self-esteem scores between the two groups at either the 38 months or 50 months posttests.

The majority of children in the AVT group received scores that fell within the typical range or above for language (79%), receptive vocabulary (68%), speech skills (84%), reading (100%) and mathematics (86%). Eighty percent (80%) of the AVT group were rated by their parents to have high scores for self-esteem. In conclusion, for this sample of children with hearing loss, Auditory-Verbal Therapy has proved to be an effective education approach.
REFERENCES (for Chapters 1, 5, and 7)


List of Appendices

Appendix 1: Principles of Listening and Spoken Language Specialist Auditory-Verbal Education (LSLS Cert. AVEd)

Appendix 2: Further descriptions of reading, mathematics and self esteem tests

Appendix 3: Speech perception results for the AVT group for recorded voice at 38 months and 50 months posttests for CNC Words and BKB Sentences

Appendix 4: Description of operational model for Hear and Say Program
Appendix 1
Principles of Listening and Spoken Language Specialist Auditory-Verbal Education
(LSLS Cert. AVEd)

The Principles of LSLS Auditory-Verbal Education are to:

1. Promote early diagnosis of hearing loss in infants, toddlers, and young children, followed by immediate audiologic assessment and use of appropriate state of the art hearing technology to ensure maximum benefits of auditory stimulation.
2. Promote immediate audiologic management and spoken language instruction for children to develop listening and spoken language skills.
3. Create and maintain acoustically controlled environments that support listening and talking for the acquisition of spoken language throughout the child's daily activities.
4. Guide and coach parents to become effective facilitators of their child’s listening and spoken language development in all aspects of the child's life.
5. Provide effective teaching with families and children in settings such as homes, classrooms, therapy rooms, hospitals, or clinics.
6. Provide focused and individualized instruction to the child through lesson plans and classroom activities while maximizing listening and spoken language.
7. Collaborate with parents and professionals to develop goals, objectives, and strategies for achieving the natural developmental patterns of audition, speech, language, cognition, and communication.
8. Promote each child's ability to self-monitor spoken language through listening.
9. Use diagnostic assessments to develop individualized objectives, to monitor progress, and to evaluate the effectiveness of the teaching activities.
10. Promote education in regular classrooms with peers who have typical hearing, as early as possible, when the child has the skills to do so successfully.

Author’s Note: The difference between this approach and LSLS Auditory Verbal Therapy is that in Auditory Verbal Therapy, it is mandatory for the parent or caregiver to be present at a session, which is always individual. In comparison, the focus of Auditory-Verbal Education is the child, with involvement of the parent but they need not be present at a session, which can be individual or group.
Appendix 2
Further description of reading, mathematics and self-esteem tests

Reading Tests

Reading Progress Tests (RPT) (Vincent, Crumpler, & de la Mare, 1997)

The Reading Progress Tests are a series of seven British tests for ages 5 to 11. They comprise a Literacy Baseline Test of pre-reading and early literacy skills and 6 tests of reading comprehension (Reading Progress Test 1 to Reading Progress Test 6). These tests provide individual or group measures of reading progress in two stages, Stage 1 (5-7 years) and Stage 2 (7-11 years) through the first 6 years of schooling. Tests are administered in a manner that ensures that children comprehend the nature of the task. Feedback is given when the method of response is incorrect, with time to correct their response. Feedback on whether the response is correct or incorrect is not given. Up to three repeats of a target word in instructions, plus practice items are allowable. Children are reminded to refer back to the text to prevent relying on memory for their responses. There are no time limits but they usually take up to 45-50 minutes to administer. Australian norms are available and percentile ranks have been used to describe a child’s level of ability.

The Literacy Baseline Test has three purposes: to provide a baseline from which to measure subsequent progress, as a screening procedure designed to identify a child likely to face difficulties in development of early reading skills, and as an appraisal of early literacy development. This test assesses existing reading and spelling ability, identification of initial sounds in spoken words and the identification of rhymes in spoken words (phonological awareness), familiarity with literacy concepts (such as knowing which words on the cover of a book are likely to be the name of the book, or which is the first word in a line of print), knowledge of letter names and letter sounds. The child is asked to underline, or otherwise mark or point to the correct response. This test was administered to Grade 1 children in the present study.

RPT1 and RPT2 are tests of reading comprehension which have two main purposes: to allow a standardised assessment of the child’s reading comprehension, and to monitor a child’s progress in reading comprehension from one assessment point to the next in comparison with the progress made by other children in the same age-group. Both tests include three main types of comprehension question: 1) identifying the meaning of individual words, 2) selection of the correct answer from a number of choices after reading a short story, non-fiction passage or poem, and 3)
choosing or supplying missing words in a short story or non-fiction passage. The majority of responses required consisted of marking one of a multiple-choice selection. These tests were administered to Grade 2 and Grade 3 children in the present study.

RPT3, RPT4, RPT5, and RPT6 are similar to RPT1 and RPT2 in construction and administration but are of a higher reading comprehension level. They were administered to Grades 4, 5, 6, and 7 children respectively in the present study.

Mathematics Tests

I Can Do Maths (Doig & de Lemnos, 2000) is an Australian test of numeracy development in the early years of schooling. Children are requested to write, draw, count and measure in response to the questions, which cover three main areas of numeracy (number, measurement and space) and are ordered by increasing level of difficulty. The complete set of questions is covered in two books, Level A (30 questions), which was administered to children in Grade 1 in the present study, and Level B (33 questions) which was administered to a child in Grade 2. All questions are read to the children to avoid performance being affected by reading ability. The test is untimed but usually takes 30-40 minutes. A short break can be given. Australian norms were available and scores were expressed as a percentile rank.

Progressive Achievement Tests in Mathematics (PATMaths) (Australian Council of Educational Research, 2005) is an Australian test of mathematics consisting of 8 tests (Test A and Tests 1 to 7), each in a separate book, and each containing separate assessments of number, space, measurement, chance and data, with later tests containing questions on patterns and algebra. Test A required 20 minutes of testing time, plus time for administration, and Tests 1 to 7 required 40 minutes of testing time. Test A was administered to children in Grade 3, while Test 1 was given to Grade 4 children, Test 2 to Grade 5, Test 3 to Grade 6, and Test 4 to Grade 7. Australian norms were available and scores were expressed as a percentile rank.

Self-esteem Tests

Insight Preschool and Insight Primary (Morris, 2002) are self-esteem indicators which can be used to explore the three key elements of a child's self-esteem: their sense of self, belonging and personal power. Insight Pre-School covers ages 3-5 years and Insight Primary covers ages 5-11 years. self-esteem is seen as a highly personal experience, unique to each individual, which can mean how a person believes in them self, how they feel when they are with other people, or how
they feel when they tackle something new or difficult. Insight Preschool consists of 24 questions, and Insight Primary consists of 36 questions, which the parent reads and responds to in writing. This can also be answered by a teacher, but in this study, the parent was asked to respond. The form of the test chosen was according to whether the child attended pre-school or primary school. Examples of questions included “Is your child usually contented?” and “Does your child try something first before asking for help?” The scoring was according to categories of whether the behaviour was observed “Most of the time” (3 points), “Quite often” (2 points), “Occasionally” (1 point), or “Almost never” (0 points). Table 2 shows the categories for interpretation of these scores.
### Appendix 3

Speech perception results for the AVT group for recorded voice at 38 months and 50 months posttests for CNC Words and BKB Sentences

<table>
<thead>
<tr>
<th>Name of Test</th>
<th>38 Months Posttest</th>
<th>50 Months Posttest</th>
<th>Wilcoxon z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CNC Words Recorded 65dBA (Quiet)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoneme Score</td>
<td>10 78.83 11.86</td>
<td>10 83.93 10.03</td>
<td>-1.192</td>
<td>0.233</td>
</tr>
<tr>
<td>Vowel Score</td>
<td>10 81.83 13.66</td>
<td>10 90.72 9.43</td>
<td>-1.863</td>
<td>0.063</td>
</tr>
<tr>
<td>Consonant Score</td>
<td>10 64.42 24.01</td>
<td>10 80 11.34</td>
<td>-0.98</td>
<td>0.327</td>
</tr>
<tr>
<td>Word Score</td>
<td>10 49.25 19.38</td>
<td>10 65.61 16.21</td>
<td>-0.912</td>
<td>0.362</td>
</tr>
<tr>
<td><strong>BKB Sentences Recorded 65dBA (Quiet)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 79.36 20.54</td>
<td>10 88.17 16.29</td>
<td>-1.779</td>
<td>0.075</td>
</tr>
</tbody>
</table>

* = Acceptable level of significance is ≤ 0.05. Progress with time for each group analysed using the Wilcoxon Signed Rank Test.
### Appendix 4

**Description of operational model for Hear and Say Program**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Program Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent guidance and coaching program follows set guidelines</td>
<td>The program follows the Principles of LSLS Auditory-Verbal Therapy (Adapted from the Principles originally developed by Doreen Pollack, 1970; Adopted by the AG Bell Academy for Listening and Spoken Language®, July 26, 2007). The program has 7 LSLS Certified Auditory-Verbal Therapists. Trainee Auditory-Verbal Therapists receive extensive training before taking a case load, and always work under supervision.</td>
</tr>
<tr>
<td>Audiology services</td>
<td>The program advocates and promotes early identification and intervention. Full audiologic services are available including diagnostics, cochlear implant program, trouble shooting and regular monitoring of hearing aids and cochlear implants. All hearing aids are owned and fitted by Australian Hearing according to the NAL protocol and assessment follows the Alexander Graham Bell Academy for Listening and Spoken Language Recommended Audiologic Protocol (<a href="http://www.agbellacademy.org/Recommended_Protocol.htm">http://www.agbellacademy.org/Recommended_Protocol.htm</a>).</td>
</tr>
<tr>
<td>Parent guidance and coaching services</td>
<td>Children and at least one parent attend once per week for 1-1 ½ hours of Auditory-Verbal Therapy. Some children in outreach areas may receive the equivalent in short blocks of therapy. Reverse integration playgroup is available (but not mandatory) once per week. There are 42 teaching weeks per year.</td>
</tr>
<tr>
<td>Diagnostic Assessments: Speech perception assessments</td>
<td>These are performed by Audiologists every 6 months for children with cochlear implants. Children with hearing aids are tested at Australian Hearing.</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Program Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Speech and language assessments</td>
<td>These are performed by the Speech/Language Pathologists, Audiologists or Teachers of the Deaf, yearly for children with hearing aids and 6 monthly for children with cochlear implants.</td>
</tr>
<tr>
<td>Professional team (including 7 LSLS Certified Auditory-Verbal Therapists)</td>
<td>- Ear, Nose and Throat Surgeons (honorary)</td>
</tr>
<tr>
<td></td>
<td>- Audiologists</td>
</tr>
<tr>
<td></td>
<td>- Teacher of the Deaf</td>
</tr>
<tr>
<td></td>
<td>- Speech Pathologists</td>
</tr>
<tr>
<td></td>
<td>- Clinical Social Worker (honorary)</td>
</tr>
<tr>
<td></td>
<td>- Psychologist (honorary)</td>
</tr>
<tr>
<td></td>
<td>- Access to other professionals</td>
</tr>
<tr>
<td>Formal parent education</td>
<td>Parent coaching and guidance is performed at every AVT session in conjunction with a formal group program of parent education held once per month, and includes a rotating range of topics and guest speakers.</td>
</tr>
<tr>
<td>Parent support</td>
<td>Clinical Social Worker and a range of programs for parents and infants, including individual, group and peer to peer support are available.</td>
</tr>
<tr>
<td>Resources available</td>
<td>Resources available include a parent, professional and child library of books and audio-visual resources.</td>
</tr>
<tr>
<td>Integration</td>
<td>- Reverse integration playgroup which includes children with typical hearing (optional)</td>
</tr>
<tr>
<td></td>
<td>- Inclusive education in mainstream from earliest possible age</td>
</tr>
<tr>
<td></td>
<td>- School visits and support for education professionals</td>
</tr>
<tr>
<td>Home visits</td>
<td>These are carried out for city families and regional families a minimum of four times per year.</td>
</tr>
<tr>
<td><strong>Characteristic</strong></td>
<td><strong>Program Description</strong></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Outside professional support</td>
<td>A range of professionals are available for referral. Clinical and family information is supplied to these professionals with parent consent.</td>
</tr>
<tr>
<td>Teen and pre-teen support</td>
<td>Specialised programs are available for developing self esteem and peer net-working for different age groups from six years of age.</td>
</tr>
<tr>
<td>Monitoring of parent satisfaction</td>
<td>Yearly survey.</td>
</tr>
<tr>
<td>Monitoring of parent knowledge</td>
<td>Yearly survey.</td>
</tr>
<tr>
<td>Outreach facilities</td>
<td>A Telemedicine program using webcam and video teleconferencing plus home/school visits 4 times per year is available. A three day Outreach Workshop (centre-based) is also available. Intensive clinic visits are made to the program where possible. A toy library is provided, with teaching resource packs sent monthly to each family.</td>
</tr>
<tr>
<td>Flexibility of services</td>
<td>- Children with additional disabilities are provided with individualised programs.</td>
</tr>
<tr>
<td></td>
<td>- Services are flexible for individual needs (e.g. distance, family circumstances, physical difficulties).</td>
</tr>
<tr>
<td>Documented goals</td>
<td>The program develops an Individual Education Program (I.E.P.) complied by the Auditory-Verbal Therapist in conjunction with parents and teachers. This is developed in accordance with a resource, I.E.P. Goalwriter (Brown, Tuohy and Walsh, 2005).</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Program Description</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Continuity of services         | ● Children with cochlear implants continue to be MAPped and monitored for all of life.  
                                | ● Children with hearing aids may reapply for assistance/trouble shooting until school age                                                                                                                          |
|                                |                                                                                                                                                                                                                       |
| Point of exit/professional     | As AVT is a form of early intervention, children formally exit the program at age of school entry, except for children receiving a cochlear implant over 4 years of age who may continue for 1-2 years into their school years. Children receiving a bilateral cochlear implant may return for around 6-12 months for audiology and therapy. |
| release                        |                                                                                                                                                                                                                       |
| Role of parents                | Parents:  
                                | ● Are recognised as the natural language teachers for their child  
                                | ● Work with Auditory-Verbal Therapists who adopt a “train the trainer” approach for parents  
                                | ● Are treated as unique and special individuals  
                                | ● Are acknowledged as primary facilitators of their child’s program  
                                | ● Become translators of their child’s communications attempts  
                                | ● Learn to become the chief advocate for their child                                                                                                           |
| Role of professionals          | Professionals:  
                                | ● Work to impart a feeling of hope to the parents  
                                | ● Ensure parents are motivated and have an expectation that their child will learn to listen and speak  
                                | ● Adhere to the Principles of Auditory-Verbal Therapy [http://www.agbellacademy.org](http://www.agbellacademy.org)  
                                | ● Transfer the role of “teachers and leaders” to the parents  
                                | ● Educate parents with the required knowledge  
<pre><code>                            | ● Develop concurrent teaching of parents, child and family                                                                                                         |
</code></pre>
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Program Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role of professionals cont.</td>
<td>members using an appropriate “coaching voice” for parents and child so each understands when they are being guided</td>
</tr>
<tr>
<td></td>
<td>• Liaise with and refer child and parents to other professionals, services or programs as appropriate</td>
</tr>
<tr>
<td></td>
<td>• Develop long and short term goals appropriate for child and family</td>
</tr>
<tr>
<td></td>
<td>• Monitor child’s progress continually with formal and informal assessments</td>
</tr>
<tr>
<td></td>
<td>• Train other professionals involved with the child in carrying out the AVT program</td>
</tr>
<tr>
<td>Cost of services</td>
<td>There was no cost to parents until 2005 when a parent levy of 10% of the child’s clinical costs was introduced. This is regularly reduced or waived in circumstances of family hardship.</td>
</tr>
</tbody>
</table>